DESIGN OF A CYCLE-CHARGED DIESEL/

RENEWABLE HYBRID POWER SYSTEM

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ABSTRACT

Objective

The objective of the study is to define the design, specifications, installation guidelines and prices for an energy-efficient 50KW cycle-charged diesel genset. It will operate as a diesel-only and will provide a technically compatible and lower-cost system when combined with wind and photovoltaic power sources.

The objectives of the diesel/renewable hybrid power system are to provide high availability of power independent of site conditions and climate, to improve economics of both the diesel and renewable subsystems. Five standard designs covering 10KW to 150KW will cover more than half the possible applications.

Methodology

A short-term peak of 50KW was chosen as a typical load. A load factor (ratio of average to peak load) was estimated using data from a prior theoretical analysis, conducted by Mechron for the National Research Council. Design calculations gave the sizes of major components such as engine, generator, station battery. Design work comprised system specification, selection of components, bill of material, drawings and cost estimating.

Report Highlights

The report will enable prospective users to specify, design, purchase and install an efficient, economical and reliable diesel/renewable hybrid power system.

Significance of Results

For the specifier and purchaser, time, money and risk have been reduced for the procurement of a hybrid power system.

The main recommendation is to produce, install and monitor a system for an appropriate user. Other studies have identified a multi-billion dollar market potential for remote sites.

A program of development, production, installation and test is a prerequisite to market development, both domestic and export.

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EXECUTIVE SUMMARY

Background and Objectives

Mechron Energy Ltd. has been a leader in Cycle-Charged Diesel (CYCLE CHARGE®) systems, whereby a diesel genset cyclically charges a station battery, which supplies energy to the load. About 32 systems, providing DC output, are in service at unattended telecommunication and navigation sites.

The CYCLE CHARGE 4000 (CC4000) system is a new design which provides AC output for outposts, stations and small communities in the power range 15 to 150KW.

This design study reduces front-end time, money and risks for specifiers and purchasers of hybrid power systems. The study provides data, specifications, drawings and prices for a 50KW system which can be adapted to cover from 15 to 150KW.

The objectives of the diesel/renewable hybrid power system are:

- To provide high availability of power, independent of site conditions and renewable-energy availability.

- To provide improved economics of both the diesel and renewable subsystems. Cycle-charged diesel systems (without renewable energy subsystem) have been proven to save more than 70% of fuel and to improve maintenance and replacement costs by a factor of 3 or 4, compared to conventional systems. Further improvements may be achieved by a hybrid system. As well, the renewable energy sources can be downsized because of the efficient and cost-effective interface provided by the cycle-charged diesel.

Method

Using prior theoretical analysis work conducted by Mechron for the National Research Council, loads and load factors were estimated. Design calculations gave the sizes of major components. Design detailing comprised specification and selection of components, bill of material, drawings and cost estimating.

Highlights, Conclusions, Recommendations

The drawings, specifications and prices, together with the information contained in this report, will enable specifiers and purchasers to acquire a reliable and energy-efficient diesel genset and to integrate it with a wind-turbine or photovoltaic system.

Theoretical studies and simulations cannot anticipate all the real-world interactive effects. Completion of this design work has provided the knowledge to produce, install and monitor hybrid or diesel-only power systems.

Successful domestic demonstrations will qualify Canadian companies for access to a multi-billion dollar market potential for remote site power.

Financial assistance should be provided for test and evaluation systems, such that the initial capital costs will be the same as if a conventional plant was acquired by the user. As well, an independent organization should monitor operating results.

Assessment of Work, Importance

There is a large market potential for diesel/renewable hybrid power systems in Canada's north and in developing countries. Canada has the diesel power technology and renewable-energy expertise to become a leader in hybrid systems.

The key to success will be a system as described in the report, proven in service, which offers:

- Capital costs not significantly higher than conventional technology.
- High availability of power, independent of site conditions and climate.
- Energy-efficiency combined with reliability, low maintenance and long life.
- Technology which is 'appropriate' for remote locations which have low skills and modest facilities for operation and maintenance.

Need for Further Work

- Test and evaluation at a real-world site is needed to obtain design feedback and operating results which would permit the following:
  - Optimal sizing (downsizing) of the battery, to match load demand with energy supply. Downsizing will improve capital costs but at some point performance will degrade and battery life will be shortened.

- Definition of the trade-off between sizing the renewable energy source (capital cost) vs. operating and maintenance costs.

1.0 INTRODUCTION

Mechron Energy Ltd.

Mechron specializes in the design and production, installation and service of highly-engineered power systems for critical applications where high reliability and low maintenance are major requirements.

Background

Mechron has produced over 32 CYCLE CHARGE prime power diesel gensets for remote, unattended communication and navigation sites. Operating results have proven greater than 70% savings in fuel compared to conventional systems. Maintenance and replacement costs have been improved by a factor of 3 or 4. Systems built to date, CYCLE CHARGE 1000, 2000 and 3000 have provided DC power to their loads, comprising telecommunications repeaters and navigation aids.

CYCLE CHARGE 4000 described in this report is designed to provide AC prime power for small stations and communities (10KW to 150KW) with energy-efficiency, low maintenance, high reliability and long equipment life.

Electrical loads smaller than several hundred KW invariably have poor load factors (the ratio of average to peak load). Thus, prime power gensets must be oversized for short peak loads, but run inefficiently and need high maintenance on load factors less than 50%. For renewable energy power sources, the power and energy generated are site and climate dependent. Thus these systems must be grossly oversized if they are to meet the peak demand under worst generating conditions.

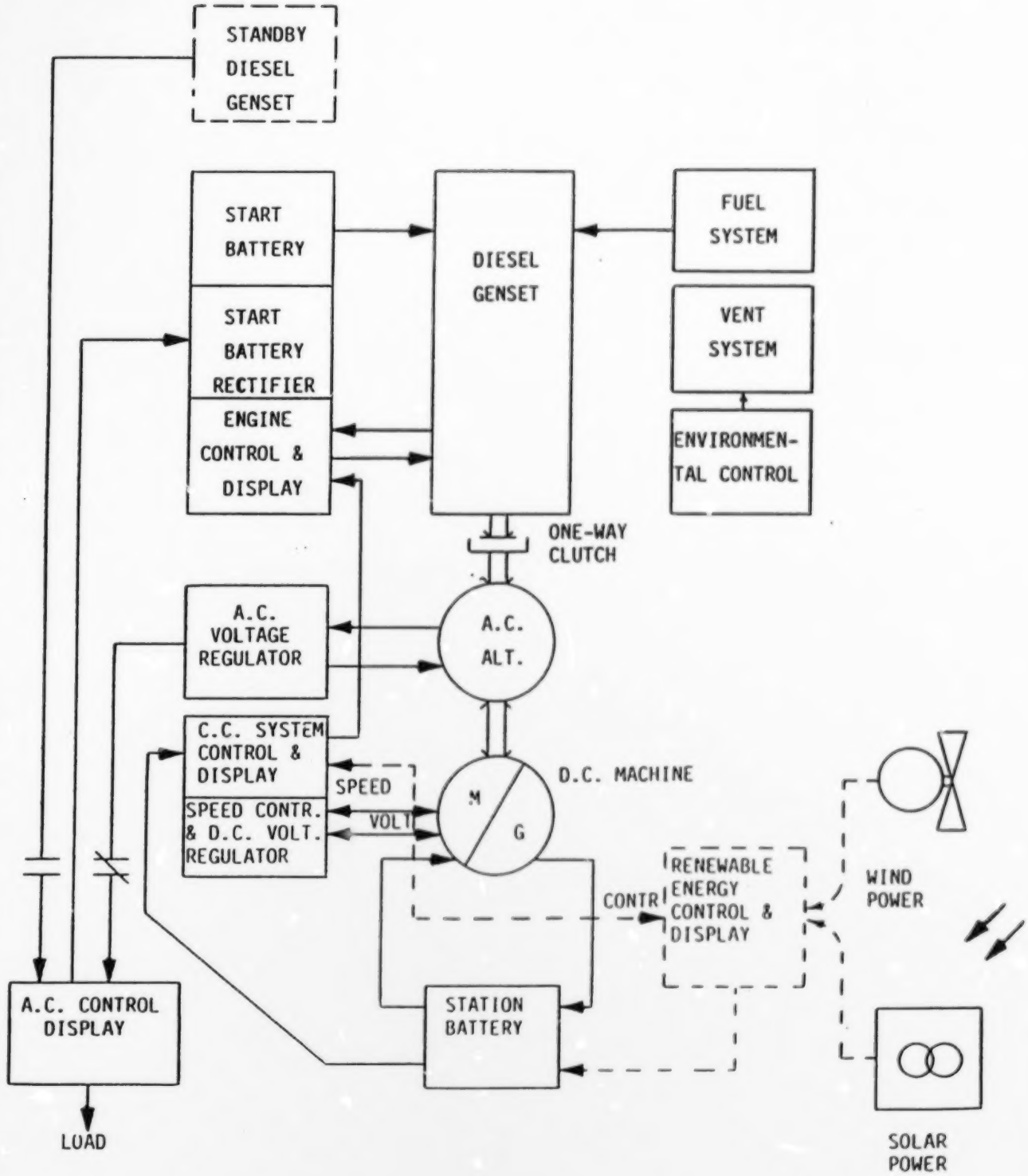
When a diesel genset and renewable source are combined in a hybrid system, benefits can be derived, but further problems can arise. A diesel genset is not a 'stiff' source and will not act as a 'sink' to stabilize the output of a directly-coupled wind turbine (WTG). When wind conditions are good, the genset will become lightly loaded with adverse effects. When winds are gusty, instability may result. The result can be two (2) oversized and uneconomical generating systems. Furthermore, when paralleling two AC sources, especially at lower powers, the generators should have nearly identical characteristics of voltage regulation, frequency regulation and waveform (harmonic content). Each AC source must be protected from damage by the other.

CYCLE CHARGE 4000 (Figure 1)

The CYCLE CHARGE 4000 system major components include a diesel engine, clutch, DC motor/generator, AC alternator and station battery. Also included are controls, switchgear, fuel and ventilation systems. The system is installed in a building with vents and fans to maintain the temperature between 5°C and 32°C.

FIGURE 1

A.C. CYCLE CHARGE - SERIES 4000



In the diesel OFF mode, the battery powers the DC motor, turning the AC alternator to supply the load. When the battery drops to 65% of amp-hour (AH) capacity, the diesel starts (ON mode) and the DC motor is connected as a generator to recharge the batteries. The system is designed so that the diesel always runs in an efficient load range. The ON cycle is typically 3 hours. On an average load, the OFF cycle is about 9 hours but becomes longer at light loads and shorter at heavy loads.

Hybrid Systems (Figure 1)

When CYCLE CHARGE is combined with WTG or PV sources at a site which has good, reliable renewable energy, a cost-effective system can be achieved, using the best characteristics of each source.

The presence of the CC4000 ensures continuous power regardless of site weather. The battery provides an interface to PV or WTG sources. It also permits the matching of load demand to supply. The WTG or PV can be downsized since it need supply only the average power under good conditions. For PV systems, battery storage capacity can be reduced.

For sites with good renewable energy, life cycle costs can be minimized. The CYCLE CHARGE will run a maximum of 25% of the time, on average, when there is no renewable energy input. The WTG or PV source will reduce this, trading off capital investment vs. reduced operating costs of the diesel.

Benefits

- High availability of power, independent of site or climate variables.
- Operating costs reduced by 70% for the CYCLE CHARGE mode and even further through renewable energy input.
- Diesel maintenance and overhauls reduced to 1/3.
- Diesel life extended by a factor of 4 times.
- Battery matches load demand to supply. Provides energy for short overloads and dips in renewable power.
- WTG or PV array and support structures can be downsized.
- Battery isolates diesel genset from 'incompatible' interfaces with WTG or PV source. Ensures stable operation.
- CC4000 is simple, conventional, rugged technology. It is easy to maintain. It will handle large surge overloads (inductive loads starting) for a few seconds. It has good ability to handle unbalanced loads.

- Redundancy can be achieved via the renewable source or by a standby diesel genset.

Canadian Market Potential

In Canada, the potential applications for diesel/renewable hybrid power systems include both communities and 'stations' or outposts and are categorized as follows:

1. Native communities.
2. Resource/industrial communities: logging, mining, exploration.
3. Government outposts: forestry, natural resources, parks, nursing stations, defense, etc.
4. Construction camps.
5. Airports.
6. Schools.
7. Meeting halls.
8. Tourist camps.
9. Communication, transportation and navigation facilities.

From Statistics Canada "Electric Power Statistics 1979", we deduce there were 328 locations having 879 diesel gensets rated at 100KW or more. From USA Dept. of Commerce Statistics, we determined that the ratio of gensets sized 14 to 100KW divided by gensets sized 100 to 400KW is 1.15. Thus, we estimate over 1000 gensets in Canada rated 14 to 100KW (the range of interest to CC4000) or some 375 locations. At about $100,000 per site, the total market potential would be 37 1/2 million for retrofit of wornout and energy-inefficient systems.

As well, there is a market potential for new systems. See also reference [2].

World Market Potential

The world market potential is indicated by the following sources:

- Electrifying the World: Editor of Solar Age references a Frost and Sullivan study, estimating a 1983 world potential for hybrid power systems of 3.0 megawatts (about 3 billion dollars) growing at 22% per annum.

- Alternative Sources of Energy, Nov/Dec 1984: President of Mobil Solar found 1983 world market for diesel electric remote sites at 2 gigawatts, or about $3 billion U.S.

- Frost & Sullivan [1]: 1990 forecast, for combined power from diesels, TEG'S, wind, solar, batteries and power conditioning. (Assumes $1 per watt for power generators).

($m in 1980 dollars)	N.Am.	Eur.	Africa	M.East	S.Am.	Asia Far East	TOTAL
a) Rural Electrification	924	1033	2272	751	731	770	6481
b) Telecommunications	12	11	9	8	8	10	58
c) Total	936	1044	2281	759	739	780	6539

Need for this Project

Energy-conserving projects such as CC4000 are hard to sell, at least initially.

Fundamentally, no one wants to be first, to pay more initially, for a new concept which promises to cost less over the longer term.

There is a need for financial assistance for the following:

1) Fixed engineering and drafting design costs.

2) Construction of a system, factory test, installation, site test.

3) Monitoring, reporting, disseminating the results.

The costs of 1) above are covered by this project and will reduce the barriers to progress to steps 2) and 3) which are prerequisites to competing for the potential markets.

2.0 OBJECTIVES

The objective of the design study is to identify the configuration, specifications, drawings, installation guidelines and prices for an energy-efficient 50KW diesel genset which provides a technically compatible and low-cost interface with renewable energy sources such as wind turbine generators and photovoltaic systems.

The objectives of the diesel/renewable hybrid power system are:

- To provide high availability of power (high reliability, low maintenance) in remote locations.
- To achieve the above, independent of site conditions and weather.
- To provide improved economics compared to conventional diesel systems.
- To provide an efficient interface with a wind turbine generator (WTG) or photovoltaic (PV) source.
- To aim the design and size at 50KW (deemed to be a popular size in Canada and export markets) but be able to scale up to 150KW, or down to 10KW if appropriate.

3.0 METHOD

Introduction

A prior theoretical analysis of the system was conducted by Mechron under a contract from Canada's National Research Council [2]. A short-term peak peak load of 50KW was assumed. A load factor (ratio of average to peak load) was estimated, using data from [2]. Thereafter the design work was conventional engineering, calculating the sizes and ratings of the power-train components, identifying major components, preparing a bill of material, drawings and a cost estimate.

Diesel/Renewable Hybrid Power Design Concept

The block diagram of the WTG and the CC4000, with their interfaces at the Station Battery are shown in Figure 1. The exact details may depend on the design of each manufacturer's WTG. The WTG is made to operate as a battery-charger (which CC4000 also does). Control protocols are exchanged between the WTG and CC4000 to minimize fuel consumption and maximize energy extraction from the WTG.

Several refinements are possible. For example, if the battery is fully charged and the WTG is generating power then the excess could be used for heating, such as hot water.

Except for the WTG tower-mounted equipment, all power equipment must be housed in a vented/heated building to control the operating environment of the equipment. (Heating not required in tropical and sub-tropical climates).

The explanation of the CYCLE CHARGE design, and the results from the NRC study, 'An Analysis of CYCLE CHARGE and Wind Turbine Hybrid Power Plants for Remote Community Applications' [2] is given in Appendix 1.

This paper was given in June, 1985. At present (February 1987) there are 32 CYCLE CHARGE systems in service. All of these are the design which produces DC power.

4.0 RESULTS

Summary

The results of this design study are presented in the following Appendices:

- A-1 Conference Paper: System Design for Diesel/Renewable Hybrid Power. This paper gives more details on the characteristics of power loads at remote locations, summarizes the design and operating results of CYCLE CHARGE for DC loads and summarizes the results of the NRC-funded study of CYCLE CHARGE for AC loads [2].

- A-2 Data Sheet: CYCLE CHARGE 4000 Diesel/Renewable Hybrid Power System.

  This data sheet summarizes the application, operating sequence, benefits, system specifications and system composition for a 50KW CC4000 diesel generating system.

- A-3 Specification for a CYCLE CHARGE 4000 Prime Power System:

  - This specification includes also the optional standby diesel gensets, single line diagram and installation designs for either a customer-owned building or Mechron-supplied relocatable buildings Weights and sizes are given.

- A-4 Drawings: Eleven drawings are provided, to assist in the planning and installation of the power system. Ten drawings show the dimensions of power units, and their typical layout in power buildings. The eleventh is a single-line electrical drawing.

- A-5 Price Summary:
  Prices are given for two major alternatives, with options for each:
  i. Equipment for Installation in Customer's Building:
  a) CYCLE CHARGE 4000 Genset and Controls
  b) Station Battery
  c) Optional Standby Diesel Genset

  2. 'Packaged Systems': Gensets Installed in Mechron Relocatable Buildings:
  a) CYCLE CHARGE 4000 Genset and Controls
  b) Building for above
  c) Station Battery
  d) Building for above
  e) Optional Standby Diesel Genset
  f) Building for above

Discussion

The report provides drawings, specifications and prices to enable specifiers and purchasers to acquire an energy-efficient diesel genset, and to integrate it with a wind-turbine or photovoltaic system.

A great deal of work has been conducted by many organizations on theoretical designs and computer simulations of combinations of renewable sources (especially WTG's) with diesel gensets. Mechron is now ready to undertake a practical approach, with installation and evaluation of a site under real weather and load conditions. Simulation cannot anticipate all the real-world interactive effects.

The difference in price between a conventional prime power system and a CYCLE CHARGE 4000 is due almost entirely to the battery. In cold climates the building is also somewhat more expensive, since it has to be well insulated and temperature-controlled to retain heat in cold temperatures and ventilate when hot.

The payback on C4000 depends mainly on:
- Fuel costs
- Maintenance and service costs
- Load factor or load duration curve. Locations which have short peaks and long periods of low load are favourable to CYCLE CHARGE. Airports, schools, meeting halls, and coastal lighthouses are excellent examples.
- Calculations of payback have fallen between 2 and 4 years.

The payback on a renewable source combined with CYCLE CHARGE depend on:
- 'Downsizing' the renewable source to carry only the average load, thus minimizing capital cost. See load factor, above.
- Site physical characterisics, such as distance from generator (mountain top) to load (valley).
- Availability of renewable energy, to match seasonal load demand and thus displace fossil fuel.
- Fuel costs, including transportation.
- Maintenance and service costs.

5.0 CONCLUSIONS

1. This design study will be beneficial to planners, consultants, specifiers, purchasers, operators, end users and power system contractors for small, remote sites. The specifications and data will permit definition of the equipment and its installation. Equally important, the design study will be beneficial to manufacturers of WTG and photovoltaic power systems as well as power system contractors.

2. The CYCLE CHARGE concept is novel, but uses conventional technology. It is thus appropriate for remote sites in less developed territories, where operation, maintenance and service facilities are limited.

3. CYCLE CHARGE solves many interface problems, between diesel genset and WTG, or between diesel genset and inverter for a PV system, and helps match load demand to energy supply. Accurate sizing of the power sources is not essential. CYCLE CHARGE will accommodate higher loads and shortfall of renewable energy by shorter OFF cycles. Lower loads and high levels of renewable energy are accommodated by longer OFF cycles.

4. CYCLE CHARGE provides an energy-efficient and dependable power source, independent of site conditions and climate. Renewable sources of smaller capacity than otherwise possible, can be utilized to make the most cost-effective hybrid system.

6.0 RECOMMENDATIONS

1. Test and evaluation, preferably of both a WTG and PV hybrid system, to obtain design feedback and operating results.

2. Test and evaluation would also permit important refinements, such as:

   - Optimal sizing (downsizing) of the battery under actual conditions. Downsizing will reduce capital costs but at some point performance will degrade and battery life will be shortened.

   - Definition of the trade-off between sizing the renewable energy source (capital cost) vs. operating and maintenance costs reduction.

3. Design of other CC4000 sizes, e.g. 10, 25, 75 and 150KW.

4. Test and evaluation is essential, as a 'testimonial,' to develop sales both domestic and export.

7.0 REFERENCES

1. Worldwide Remote Site Power Systems, Vol. I and II. Frost and Sullivan Inc., 1983.

2. An Analysis of CYCLE CHARGE and Wind Turbine Hybrid Power Plants for Remote Community Applications. National Research Council, Ottawa, Canada, TM-WE-026, March, 1985.

8.0 APPENDICES

A-1 Conference Paper:
System Design for Diesel/Renewable Hybrid Power

A-2 Data Sheet:
CYCLE CHARGE 4000 Diesel/Renewable Hybrid Power System

A-3 Specification:
CYCLE CHARGE 4000 Diesel Prime Power System

A-4 Drawings

A-5 Price Summary

APPENDIX A-1

Conference Paper: System Design for Diesel/Renewable Hybrid Power
(11 pages)

June 1985

SYSTEM DESIGN FOR DIESEL/RENEWABLE HYBRID POWER

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ABSTRACT

Two cycle-charged diesel (CCD) power systems are described, for remote sites and small communities, which achieve high efficiency and reliability combined with low maintenance. Intermittent diesel operation (about 25% duty cycle) while charging a station battery permits high loading on the genset despite power demands which have a poor load factor (the ratio of average-to-peak power). The station battery provides an efficient interface for photovoltaic (PV) and wind-turbine (WTG) sources. Conventional small diesel power systems (15kW to 150kW) for remote locations are installed with more capacity than the worst expected peak and are operated at a 100% duty cycle. Low load factors cause the generating plant to run lightly loaded most of the time. This results in poor efficiency, low reliability and high maintenance. Operating results are given for CCD systems in service and for the results of a wind/CCD hybrid study.

KEYWORDS

Hybrid power systems, diesel, photovoltaic, wind-turbine, wind energy converter.

INTRODUCTION (Figure 1)

A diesel generator burns less fuel, runs more reliably, and requires less maintenance when it runs intermittently at full load than if it runs continuously at low load. By charging batteries when the genset is operating, energy is stored to be available on demand by the load. This principle can be applied to power generation for remote sites, and small communities having peak power demands in the range 15 to 150kW.

The availability of renewable energy is site- and weather-dependent, so is unlikely to match load demand. The station battery provides an efficient interface with the diesel, the renewable source and the load. Inefficiencies and incompatibilities of paralleling AC generators are eliminated.

UNATTENDED REMOTE SITES

Load Characteristics (Figure 2)

Navigation beacons and communication repeaters require about 500 to 1000 watts for the steady-state electronic load which usually is direct current (DC). Other equipment such as rectifiers, cooling, heating, dehydrator, tower lights and maintenance accessories result in a peak load of 8 to 9kW. The diesel room has a peak load of 2 to 3kW for start-battery rectifiers, fuel pumps, cooling fans, engine heaters and maintenance accessories. Total load is 10 to 12kW. Thus the load factor is about 15 to 18%.

Direct-Current Cycle Charging Diesel System (Figure 3)

A diesel genset, with a full-load rating in the range of 8 to 15kW, charges a station battery which supplies the DC load. The diesel ON cycle is typically 3 hours, to load the genset to about 80% of capacity. The OFF cycle depends on the load which varies for a number of reasons including heating and cooling demands. The OFF duration is designed to be about 9 hours but the actual OFF time may extend to 24 hours or more if the load becomes small. The station battery is sized to match both the load drain and the diesel-charging cycle and is usually 1000 to 2000 ampere hours (AH) in capacity.

A unique alternator and controller has been designed which is small in size, uses few parts, and provides both DC for the load and alternating current (AC) for maintenance purposes. If a steady AC load must be supplied, then an inverter is required.

Operating Projections and Results

The system has been pioneered by Newfoundland Telephone, Transport Canada and the Canadian Coast Guard. In total, 20 systems are in service and fuel savings have been proven to be 70%, with similar savings in maintenance.

After a trial in 1982, Newfoundland Telephone projected that retrofit of 13 sites and 7 new installations would save $9,300,000 over 20 years. At present (June 1985), they have 8 systems in service and 5 being installed.

A study by Marbek Resource Consultants, funded by the Ontario Ministry of Energy, forecasts savings for 11 Ontario sites of $3,137,000 over 20 years. Payback falls between 3.7 and 4.6 years.

REMOTE COMMUNITIES

Background

Based on experience with DC systems, a conceptual design was identified of a cycle-charging diesel system suitable for communities up to 150kW peak AC load and suitable for hybrid combination with WTG or PV sources. In January 1984, the National Research Council (Canada), Wind Energy Group, funded an economic and design study [1] of a system for a typical 50kW peak community. To limit the study complexity, one community was selected having an average wind speed of 23 km/hr. The following 39 system alternatives were studied:

System Characteristics	Alternatives
- Conventional, dual prime power diesel	1
- Dual cycle-charged diesel, 3 battery sizes	3
- Wind/CCD hybrid, 3 WTG sizes	9
Equipment configurations:	13
- 3 fuel costs @ $Cndn. .30, .90, 1.50/litre	3
Total alternatives:	39

General Community Characteristics

Community load demand varies seasonally due to heating and population; daily due to mealtime and leisure activities and short-term due to inductive loads if there is industrial activity. The study required knowledge of community loads, but we found that usually only monthly-peaks are recorded, averaged over a 15-minute period. The size of short peaks are unknown as is the Load Duration Curve (LDC). Conventional practice is to install a generating capacity of twice the yearly 15-minute peak. Dual or triple gensets are installed and run singly or in parallel, to achieve higher loading than using one large machine. Typically, the diesel load is low, but when the load exceeds 100% the genset will shut down for self-protection.

The foregoing reveals the fallacies of AC (or grid) coupling a WTG to small diesel generators. The genset may not be "stiff" enough to synchronize the WTG. Harmonic and reverse current mismatch of one generator vs. another may cause interference. When wind energy is good, and load is normal, the diesel becomes lightly loaded. When the wind energy disappears, the genset may experience sudden overload.

Load Characteristics (Figure 4)

Load data for small communities in Canada was not adequate for the study, so available data was combined with a detailed survey of one community. A Load Duration Curve was constructed of load vs. percent of time equalled or exceeded for a 'generic' 50kW peak community. The average load is about 35% of peak. About 4% of the time, the loads exceed 40% of yearly peak. Since the installed capacity is usually twice the 15-minute yearly peak, the percentage loading on the generator is half the above values.

Alternating-Current Cycle Charging Diesel System (Figure 5)

This system design avoids the use of inverters and exploits the excellent overload and short-circuit characteristics of rotating electrical equipment. A diesel drives via a one-way clutch both an AC generator and a DC motor/generator. The AC generator supplies the load. During the ON cycle, the DC machine acts as a generator to charge the station battery. During the OFF cycle, power from the battery drives the DC machine as a motor, to continue the drive of the AC generator.

DIESEL/RENEWABLE HYBRID SYSTEMS (Figures 3 and 5)

In both the DC and AC versions described above, the interface with the renewable source is via the station battery. This has the following advantages:

- The complexities of AC-coupling of two unlike AC generators is avoided. The interaction and interference of one system on the other is eliminated.
- The PV array or WTG and tower can be downsized to supply the average load.
- The battery reserve need not supply the no-sun or no-wind days and thus can be downsized. Typically, 1000 ampere hours is adequate.
- The diesel-generator-battery combination takes care of the worst-case peaks of load and the worst season deficiencies in availability of renewable energy.
- High availability of power can be achieved. Similar diesel-only systems have achieved 99.99783% in service.

BATTERY CHARACTERISTICS

Lead-antimony or lead-selenium batteries are preferred for most applications. They are cycled over a regime from 95% to 65% of AH capacity (a 30% range) and under these conditions the expected cycle life is 5000 or about 10 years.

For extreme climate applications, recombinant (starved) electrolyte lead-acid batteries or nickel-cadmium batteries promise added life.

ECONOMIC ANALYSIS OF CYCLE-CHARGED DIESEL/ WIND TURBINE HYBRID FOR REMOTE COMMUNITIES [1]

The following is a summary of the referenced study.

Cost/Performance Data and Analysis

Data was developed and analysed as follows, for the 13 alternative system configurations described above.

- Daily and monthly energy demand profiles were used to develop community energy consumption.
- Capital, installation and maintenance costs were estimated, based on the design of each system alternative.
- The net fuel efficiency of conventional prime power systems was obtained from 16 isolated communities in 4 Canadian provinces. The range was from 1.19 to 2.86kWh/ℓ. An average of 2.1 was used.
- Net fuel efficiency for the CCD was done by analysis and simulation, starting from the gross engine efficiency and deducting system losses. Simulation established the diesel ON cycle for each of 12 CCD and CCD/WTG alternatives.
- Battery life and maintenance was estimated by prediction/simulation of cycle life. Three simulations were run: 887, 1775 and 3547 AH.
- WTG characteristics were synthesized from commercially-available data for horizontal and vertical axis machines. WTG 'nominal' size selected was that which at average wind speed could theoretically produce the yearly energy requirements of the community (230MWh). The other two sizes were 1/3 (75MWh) and 2/3 (150MWh). In terms of power, these three sizes translated to 170kW, 55kW and 125kW respectively. The wind regime chosen was St. Anthony's, Nfld. Hourly wind data was used to calculate average monthly

WTG energy output, over a typical year.

- The 13 alternative systems were analysed for 20-year life-cycle costs, with a 7% annual discount rate, net of inflation, for three different fuel costs. The conventional dual prime power system was used as the base case, and savings of the other 12 were compared against it, as indicated below:

Results [1] (Figure 6)

- The CCD systems show a benefit in cost-per-kilowatt-hour of 5-10% at $.30/ℓ rising to 16-20% at $1.50/ℓ. Benefits are only slightly improved (2-4%) at the lower AH battery size.
- The CCD/WTG hybrid systems show more-significant benefits than the CCD system (again compared to the conventional system), but only at fuel costs above $.45/ℓ.

The results for CCD/WTG hybrid alternatives are tabulated below for the two higher fuel costs. The range of benefits (%) is due to the effect of battery size and this effect is small. Generally the smaller battery was preferable.

WTG SIZE (kW)	FUEL COST ($/ℓ)	RANGE OF BENEFITS (%)
55	.90	20 to 22
55	1.50	29 to 31
125	.90	25 to 27
125	1.50	39 to 41
175	.90	27 to 28
175	1.50	45 to 47

CONCLUSIONS

1. The cycle-charged diesel is a method of achieving high genset loading when there are low load factors. The benefit is overall lower cost of electricity.
2. The presence of the diesel and station battery permit an efficient interface plus technical compatibility with PV and WTG power sources. PV and WTG can be downsized and battery capacity can be minimized.
3. The savings indicated may be exceeded under the following circumstances:
   .Conventional prime power system produces less than 2.1kWh/ℓ in service.
   .Wind-profile is higher than studied, or fuel costs are higher.
   .WTG and site characteristics are optimally matched.
4. The analytic design tools which were developed under the NRC contract permit optimum hybrid system design. Whether the hybrid proves economically superior depends upon availability of renewable energy at the site and cost of fuel saved.

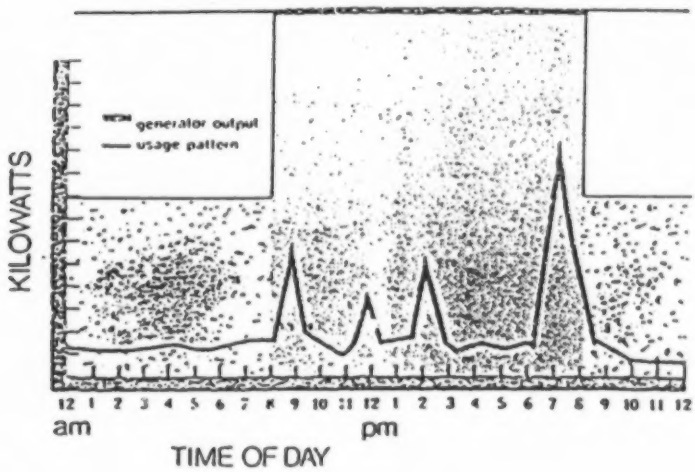
REFERENCES

1. An Analysis of CYCLE CHARGE® and Wind Turbine Hybrid Power Plants for Remote Community Applications. National Research Council, Ottawa, Canada, TM-WE-026 March, 1985.

FIGURE 1

SUPPLY VS. DEMAND

(A) CONVENTIONAL ENGINE GENERATOR



(B) CYCLE CHARGED DIESEL

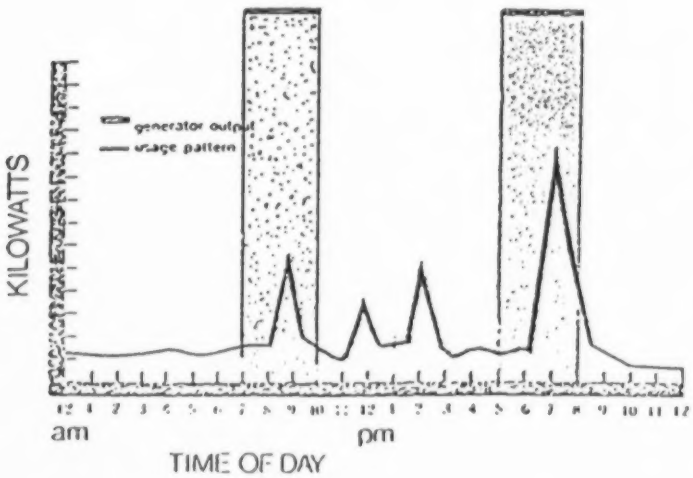


FIGURE 2

SAMPLE LOAD CALCULATION, REMOTE RADIO SITE

RADIO ROOM LOADS:

	WATTS
ASSUME RADIO LOAD IS 750 WATTS	
RECTIFIERS 2 x 50 AMP 24 V.D.C. =	2800
COOLING FAN & MISC. VENTS	700
LIGHTING 4 80 WATT FIXTURES	320
DEHYDRATOR	600
HEATING 2 x 1500 WATT	3000
TOWER LIGHTS 4 x 130	520
WALL PLUGS OUTSIDE LIGHT, ETC.	700
	8640

NOTE: IF COOLING FAN IS SUBTRACTED LOAD WILL BE APPROX. 8.0 KW

DIESEL ROOM LOADS:

BATTERY CHARGING RECTIFIERS x 2	400
FUEL LIFT PUMPS	800
COOLING FAN	500
LIGHTING & WALL OUTLETS	700
ENGINE HEATERS	250
	2650

LOAD = 2.7 KW

RESULT: _____ : _____

MOST PRIME POWER SITES ARE 10-15 KW 11290

FIGURE 3

D.C. CYCLE CHARGE SERIES 2000

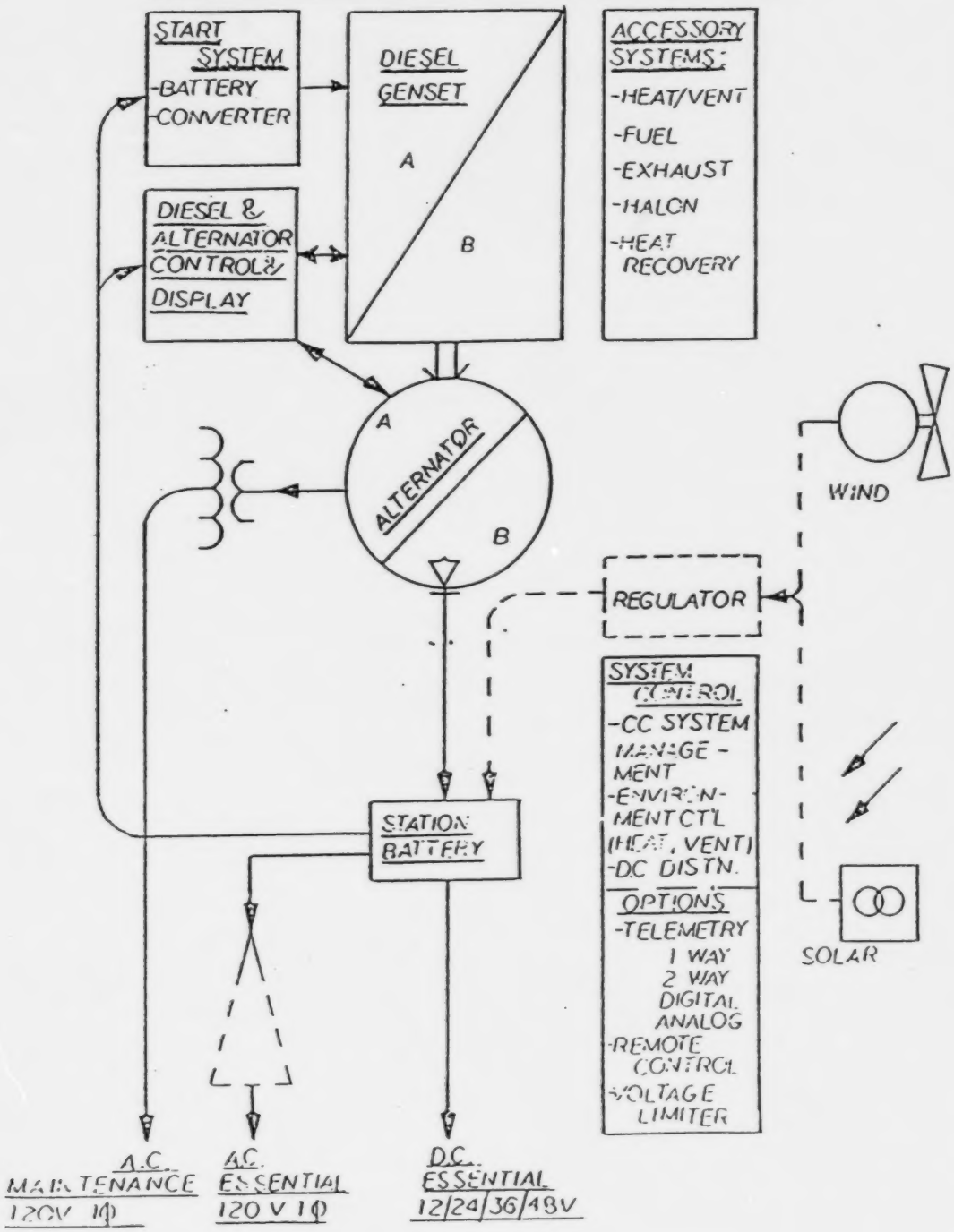


FIGURE 4

GENERALIZED AVERAGE DAILY POWER DURATION CURVE FOR A TYPICAL REMOTE COMMUNITY

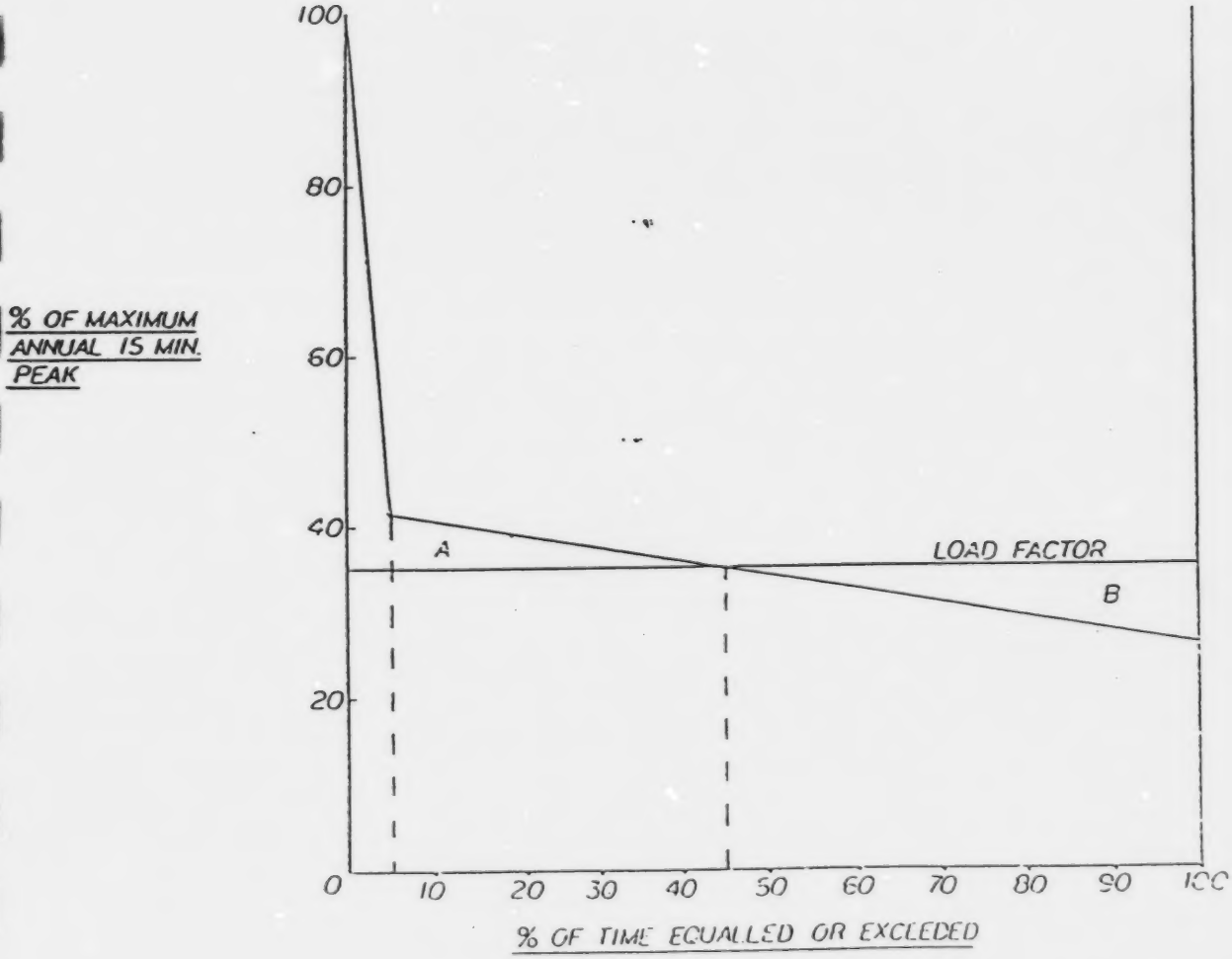


FIGURE 5

A.C. CYCLE CHARGE - SERIES 4000

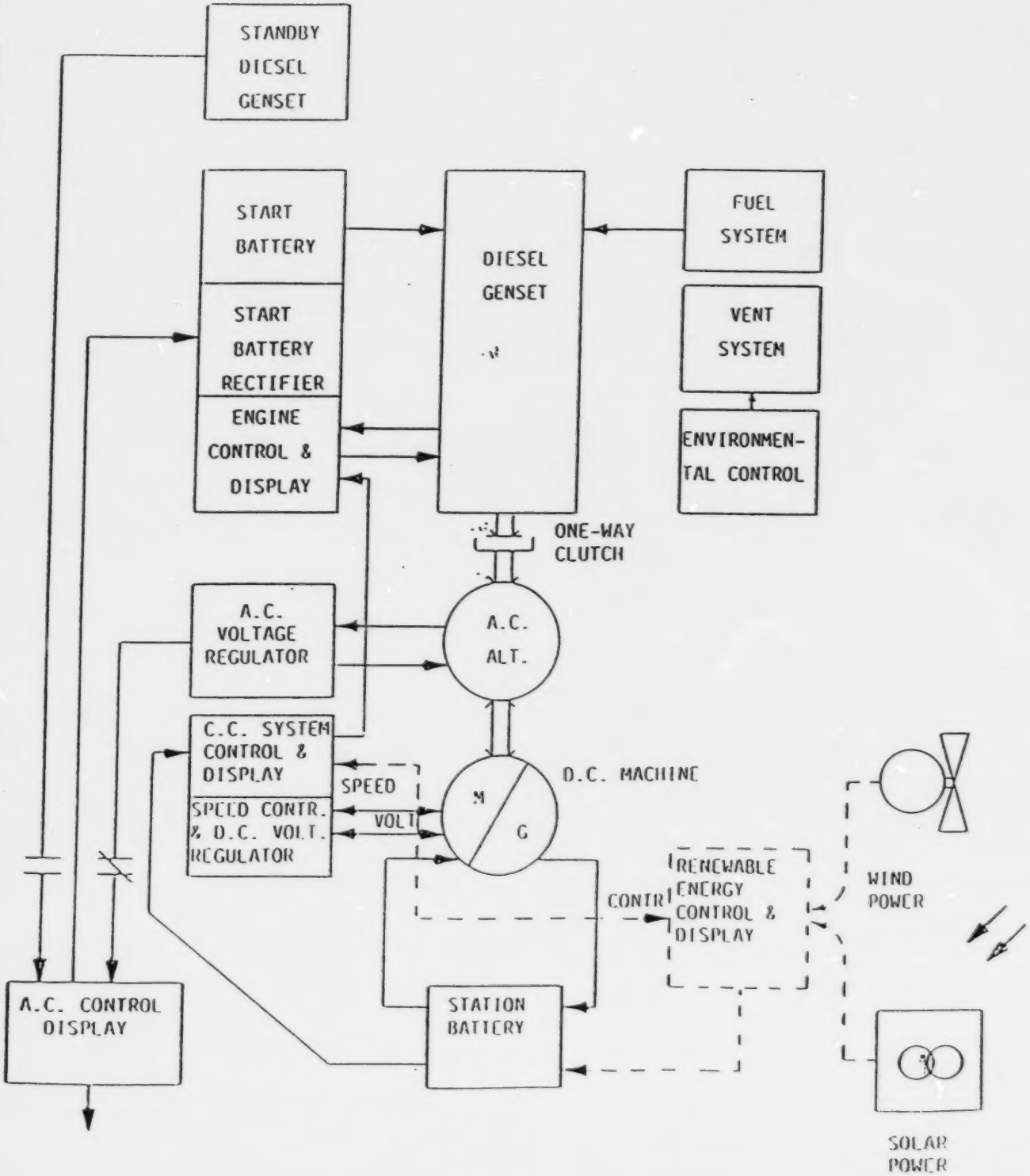
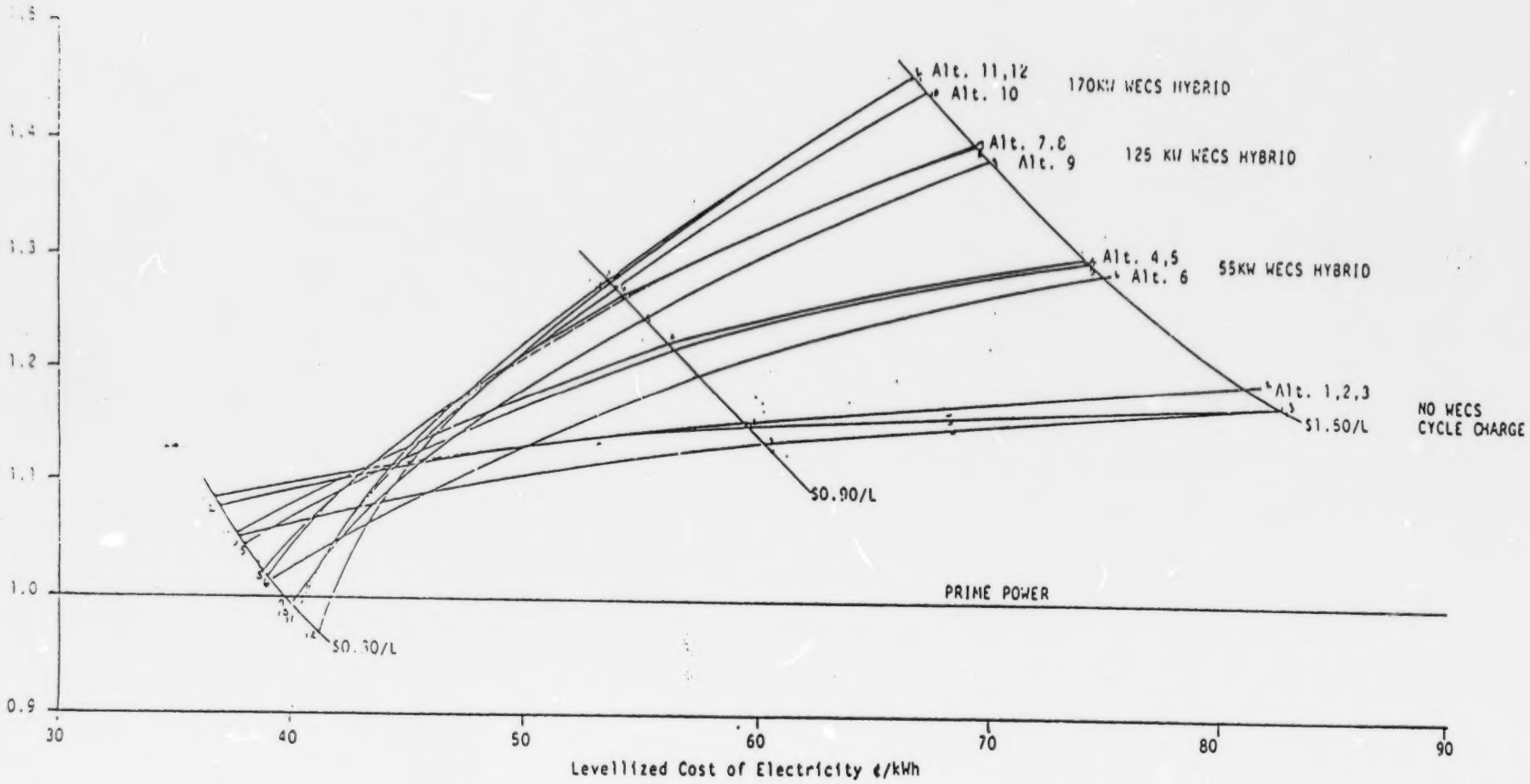


FIGURE 6

ECONOMIC COMPARISON OF THE ALTERNATIVES



APPENDIX A-2

Data Sheet: CYCLE CHARGE 4000 Diesel/Renewable Hybrid Power System (4 pages)

CYCLE CHARGE ®4000
DIESEL/RENEWABLE
HYBRID POWER SYSTEM

Preliminary: December 1986

BACKGROUND:

CYCLE CHARGE 4000 is designed to provide prime power for small stations and communities (15KW to 150KW) with energy-efficiency, low maintenance, high reliability and long equipment life.

Small loads invariably have poor load factors (the ratio of average to peak load). Thus, prime power gensets must be oversized for short peak loads, but run inefficiently and unreliably on load factors less than 50%. For renewable energy power sources, the power and energy generated are site-dependent and climate-dependent. Thus these systems must be grossly oversized if they are to meet the peak demand under worst generating conditions.

When a diesel genset and renewable source are combined in a hybrid system, benefits can be derived, but further problems can arise. A diesel genset is not a 'stiff' source and will not act as a 'sink' to stabilize the output of a directly-coupled wind turbine (WTG.) When wind conditions are good, the genset will become lightly loaded with adverse effects. When winds are gusty, instability may result. The result can be two (2) oversized and uneconomical generating systems. Furthermore, when paralleling two AC sources especially at lower powers, the generators should be as nearly identical as possible. It is not wise, for example, to parallel an inverter (operating from a photovoltaic (PV) battery) with a similar sized diesel generator.

CYCLE CHARGE:

The CYCLE CHARGE 4000 system comprises a diesel engine, clutch, DC motor/generator, AC alternator and station battery. As well there are controls provided and the system is installed in a building with vents and fans to maintain temperature between 5° and 32°C.

In the diesel OFF mode, the battery drives the DC motor, turning the AC alternator to supply the load. When the battery drops to 65% of amp-hour (AH) capacity the diesel starts (ON mode) and the DC motor is connected as a generator to recharge the batteries. The system is designed so that the diesel and generating components always run an efficient (heavy) load. The ON cycle is typically 3 hours. At average load the OFF cycle is about 9 hours, but becomes longer at light loads and shorter at heavy loads.

HYBRID SYSTEMS:

When CYCLE CHARGE is combined with WTG or PV sources at a site which has good, reliable renewable energy, a cost-effective system can be achieved, using the best characteristics of each source.

The presence of the CC4000 ensures continuous power regardless of site weather. The battery provides an interface to PV or WTG sources which is technically superior and cost effective. It also permits the matching of load demand to supply. The WTG or PV can be downsized since they need meet only the average power under good conditions. For PV systems, there is no longer a need for battery autonomy of many days or weeks.

For sites with good renewable energy, life cycle costs can be minimized. The CYCLE CHARGE will run 25% of the time, on average, when there is no renewable energy input. The WTG or PV source will further reduce fuel consumption, trading off capital investment vs. reduced operating costs of the diesel.

BENEFITS:

High availability of power, independent of site or climate variables.

Operating costs reduced by 70% for the CYCLE CHARGE mode and even further through renewable energy input.

Diesel maintenance reduced to 1/3. Life extended by 4.

Battery matches load demand to supply. Provides energy for short surges in load and dips in renewable power.

WTG or PV array plus battery and their support structures can be downsized.

Battery isolates diesel genset from 'incompatible' interfaces with WTG or inverter on PV source. Ensures stable operation.

CC 4000 is simple, conventional, rugged technology. It is easy to maintain. It will handle large surge overloads (inductive loads starting) for a few seconds. It will handle unbalanced loads better than an inverter will.

Redundancy can be achieved via the renewable source or by a standby diesel genset.

SYSTEM INTEGRATION AND INSTALLATION:

The most cost-effective system will result from a load analysis, site survey and design of an integrated system. Mechron has the expertise and experience to work with consultants, contractors and other suppliers of WTG and PV systems to design, supply, install and commission power systems at remote sites and where harsh climates prevail. Supporting services include training, service, parts as well as maintenance or service contracts.

STANDARD MODELS:

CYCLE CHARGE 4000 can be designed in five (5) standard models, from 10 to 150KW. We recommend that the system be integrated into Mechron's Packaged System buildings, unless the customer provides a suitable building which can be upgraded to Mechron's standards for insulation, ventilation, etc.

SPECIFICATIONS FOR 50 KW SYSTEM:

Output Rating:
- 120/240 VAC +/- 3%, 60 Hz, 0.8 pf

or:
- 120/208 VAC, 3 phase
- Overload 10% for 1 hour in 12 at 80°C rise over 40°C ambient. Surges of 300% for 2 seconds.

Input Characteristics:
Diesel fuel

or: Battery interface (typical):
- 250 VDC +/- 5% from 'recharge to float'
- 297.5 VDC at equalize
- 228.7 VDC to low voltage disconnect/alarm

Battery Reserve: (typical)
- 1000 AH nominal
- approx. 3 hours reserve at average load to 'recharge' point.
- Up to 9 hours reserve at average load, to low voltage disconnect.

SYSTEM COMPOSITION:

1a. CYCLE CHARGE 4000 Diesel Genset. Controls for engine, engine-start alternator, DC machine, cycle charging of battery. Displays and alarms for engine, output to load. Accessories include day-fuel system, silencer, vent to exhaust hot air to adjacent building.

1b. Environmentally-controlled relocatable building for above.

2a. Station battery, racks, connectors. Accessories include cables, to and from DC machine

2b. Environmentally-controlled relocatable building for above.

3a. OPTIONAL: Standby diesel genset. Same engine, alternator and relevant controls and accessories as for 1 above. Automatic transfer switch.

3b. Environmentally - controlled relocatable building for above.

4a. OPTIONAL: PV system from Mechron or other supplier WTG system from other supplier.

SYSTEM SIZES/WEIGHTS:	LB.	KG.
1. System to be installed in Owner's Building: Building typical floor area: 11.28 x 4.8768 metres.		
a) CYCLE CHARGE 4000	7,155	3,250
b) Batteries, racks	31,000	14,090
c) Standby Diesel Genset	5,845	2,660
TOTAL	44,000	20,000
2. Packaged System, Relocatable building: Each of 3 buildings typically 6.09 metres long, 2.59 metres wide, x 2.59 metres high.		
a) CYCLE CHARGE 4000 'Module'	12,700	5,730
b) Battery 'Module'	36,000	16,640
c) Standby 'Module'	10,800	4,910
TOTAL	59,500	27,280

APPENDIX A-3

Specification: CYCLE CHARGE 4000 Diesel Prime Power System

March 2, 1987

TECHNICAL SPECIFICATION - E58-8612

FOR A MODEL CC4000

CYCLE CHARGE®PRIME POWER SYSTEM

TABLE OF CONTENTS

1.0 General

2.0 Applicable Regulatory Documents

3.0 Design Objectives

4.0 Design Standards

5.0 System Composition

6.0 CC4000 Power System Operation

7.0 CC4000 Diesel-Generator Unit

8.0 Fuel System

9.0 Exhaust System

10.0 Engine Start Battery

11.0 Start Battery Charger

12.0 Environmental Control System

13.0 CYCLE CHARGE DC Control Panel

14.0 CYCLE CHARGE AC Control Panel

15.0 CYCLE CHARGE System Control Panel

16.0 Station Battery

17.0 Station Distribution

18.0 Buildings

19.0 Standby Genset (Option)

20.0 Installation

21.0 Transport

22.0 Tests

23.0 Documentation

24.0 Warranty

25.0 Performance Monitoring (Option)

TECHNICAL SPECIFICTION

FOR A MODEL CC4000

CYCLE CHARGE® PRIME POWER SYSTEM

1.0 GENERAL:

This specification covers the general electrical and mechanical requirements for a complete CYCLE CHARGE Diesel Power Generating System for remote community and outpost applications. The equipment supplied shall be capable of providing regulated AC power to the customer's load. The CC4000 shall include all components required to interface with the building distribution system to provide uninterrupted power continuously. The system will also interface with Wind Turbine Generator (WTG) and Photovoltaic (PV) sources and small hydro plants.

2.0 APPLICABLE REGULATORY DOCUMENTS:

The following documents apply to the specified equipment to the extent defined herein:

- Canadian Electrical Code
- Ontario Electrical Code
- Canadian Standards Association
- U.L.C. Standards
- National Building Code

3.0 DESIGN OBJECTIVES:

Provide a system for:

- Low Maintenance
- High Reliability
- Low Fuel Consumption

- Provide high availability of power in remote locations, independent of renewable energy availability at the site.

- Provide an efficient interface with WTG and PV by means of short-term energy storage in a station battery.

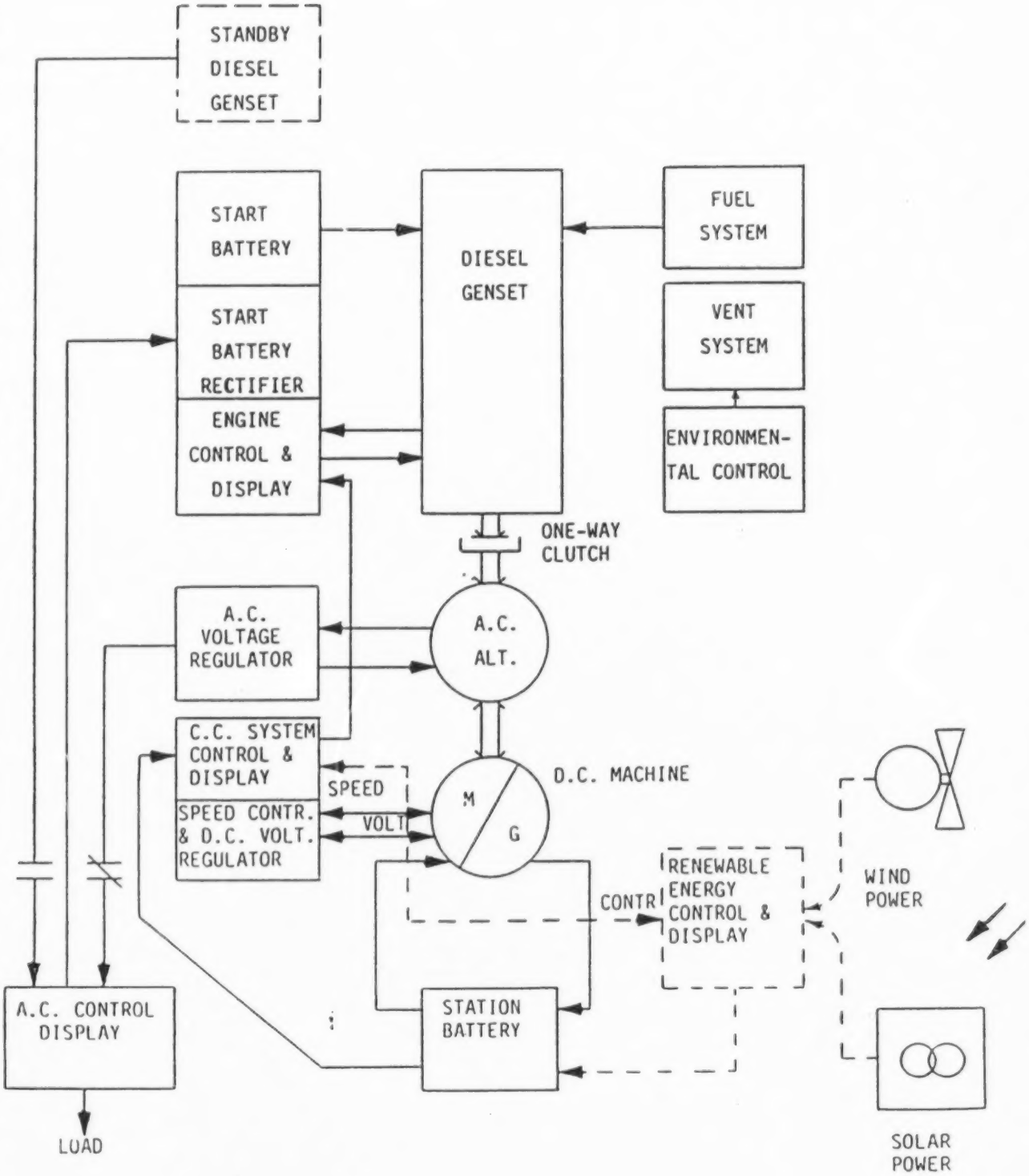
- To provide the system in a "Packaged System" building for security, environmental control, efficient operation and lower cost field installation. It is also possible to retrofit CC4000 to an existing building.

- To provide improved economics compared to conventional diesel systems, where the load factor power duration curve is low.

- A block diagram (Fig 1) shows that the basic CC4000 will operate independently of WTG, PV and the standby diesel genset.

FIGURE 1

A.C. CYCLE CHARGE - SERIES 4000



4.0 DESIGN STANDARDS:

The CC4000 shall be designed to high engineering standards and conform to the standards of Canadian electrical utilities. The specification which follows is, in part, modelled on Ontario Hydro documents.

5.0 SYSTEM COMPOSITION:

The CC4000 consists of the following major modules, sub-systems or major components: (Where applicable they are provided on both the CC4000 and the standby genset.)

- 50KW CC4000 diesel genset comprising baseplate-mounted engine, one-way clutch, alternator, DC machine, lubricating and cooling systems, gauges.
  - . Exhaust System
  - . Fuel System: Day Tank and Transfer Pump
  - . Engine Start Battery
  - . AC/DC Rectifier for Start Battery
- CYCLE CHARGE DC Control Panel:
  - . DC Metering
  - . DC Charging Regulator/Motor Speed Regulator
  - . DC Control, Low Voltage Indicator/Alarm, Low Voltage Disconnect
  - . Load Control, Main Breaker
- CYCLE CHARGE AC Control Panel:
  - . AC Metering
  - . Engine Control
  - . AC Voltage Regulator
  - . Current Transformers
  - . Breaker
- CYCLE CHARGE System Control Panel:
  - . Programmable Controller
  - . Control Functions and Outputs
- Station Battery:
  - . Battery Racks, Connectors
  - . Main Breaker
- Station Distribution:
  - . Main Breaker
  - . Distribution Panel
- Environmental Control System:
  - . Supplied standard with factory-built relocatable buildings
  - . Specially designed for for fixed building(s).
- Documentation for Operation, Maintenance and Service

OPTIONS

- Standby Diesel Genset, similar to CC4000 but no DC machine, or one-way clutch.
  . Standby AC Control Panel, c/w Engine Control, AC Voltage Regulator, AC Metering, Main Breaker

- Automatic Transfer Panel, for use with above.
  . Automatic Start, Automatic Transfer

- Environmentally-controlled Relocatable Shelters. One each for CC4000, Station Battery, Standby Genset. System can also be retrofitted or installed in fixed buildings.

- Performance Monitoring System.

6.0 CC4000 POWER SYSTEM OPERATION:

The basic operation shall be as follows. (Assume station begins operation with fully charged batteries.)

- In the diesel "OFF"mode, the DC machine will operate as a motor, driving the AC generator.

- In the diesel "ON" mode, the DC machine will operate as a battery-charging generator with the appropriate voltages for Float and Equalize, and the appropriate modes of current limit and voltage limit. For some maintenance-free batteries (if used), the Equalize mode will not be required.

- The speed of the DC machine shall be regulated to 1800 RPM (60 Hz.) +/-1% over the following conditions:
  - 15% to 100% full load
  - Temperature rise 80°C over 40°C ambient
  - Battery voltage from 247.5 to 272.2V (9.6%)

- The system is desiged so that, at an average load demand, the "ON" cycle will be 25% (approx. 3 hours). At higher loads, the "OFF" cycle will be shortened and at lower loads it will be extended. The system will also cycle "ON" if the building(s) demand heat to maintain 5°C inside.

7.0 CC4000 DIESEL-GENERATOR UNIT:

7.1 Diesel Generator Set:

- Units shall be close coupled design, mounted on a rigid fabricated steel base, of sufficient strength to prevent any flexing during transit, installation and operation and to maintain accurate alignment at all times. The base is to be designed to allow access to the crankcase for overhauls.

- Engine-base isolators shall be Korfund spring type Series L. or equivalent to support the unit from the floor, sized to suit the unit and in accordance with manufacturer's recommendations, secured to the floor via threaded steel anchor bolts, isolating pads and washers.

- Unit vibration levels must not have a displacement greater than 6 mils. or a velocity in excess of 10.16 mm/sec.

- The base shall be fitted with rear mounting feet or jack screws, designed to support the engine when the clutch or coupling requires disconnecting.

7.2 Engine:

The diesel engine shall be as follows:

- 1800 RPM continuous duty
- Rated for and capable of driving a 50KW generator, be capable of 10% overload for 1 hour in 12
- Maximum ambient 40°C
- Derated for altitudes above 304.8 metres
- Complete with the following:
  . Dry air cleaner
  . 3% mechanical or electronic governor
  . 24 volt electrics
  . Engine-mounted radiator /w fan and shroud
  . Low oil pressure switch N.C.
  . High coolant switch N.O.
  . Front and rear mounting feet
- Engine coolant pump capable of driving the external load at a flow rate which would give a maximum of 5°C temperature differential across the engine at 100% rated load or as per the engine manufacturer's recommendations.
- Engine-driven alternators are unacceptable. An idler pulley is to be provided in lieu of any alternator pulleys designed for 20,000 hours service.
- The crankcase oil must be easily drained and replaced, the crankcase is to be capable of being completely drained via flexible hose from a gate valve mounted on the sump to the rigid steel base where it is to be positioned 15.24 cm above the floor level, plugged at that point. If 15.24 cm cannot be maintained, an auxiliary pump is to be supplied with the unit.
- An oil level switch gauge shall be fitted on a stand bolted to the floor near the unit to indicate the level of the oil in the crankcase. It shall be clearly labelled to show normal operating level at rated RPM.
- All exposed rotating parts shall have guards over them, all high heat surfaces shall be insulated to protect operating personnel from injury.
- The engine starting system shall be 24VDC. The starting battery shall be charged by a 120VAC to 24VDC solid state rectifier/charger.

7.3 Engine Gauges:

The following gauges are to be mounted on a stand near the engine to minimize the transmission of vibration to the gauges:
- Lube oil pressure
- Lube oil temperature
- Coolant temperature
- Exhaust temperature

- All pressure gauges must be accurate to within 13.78KPA, and must not fluctuate more than 6.89KPA.

- All temperature gauges must be accurate to within 1°C.

- Switch gauges are to suit engine manufacturer's specification.

7.4 Unit Accessories:

The following items are to be supplied:
- Drip pan sized to suit the unit
- Lifting eyes on base, engine and generator

7.5 Dry Sump Lubrication System:

- A dry sump lubrication system is to be provided on the CC4000 genset only. This system is to have sufficient capacity and additional filtration to extend the time between oil changes from 250 hours to 10,000 or 20,000 hours of operation.

- This system to be complete with all pipe fittings, hoses, reservoir and all items comprising a working system.

7.6 CC4000 Alternator Characteristics:

- 50KW, 62.5KVA, 60 Hz., .8PF 120/208 120/240 volts AC, 1800RPM with direct connected rotating brushless exciter, 12 wire reconnectable.
- Continuous duty
- 80°C rise in temperature over 40°C ambient
- 10% overload 1 hour in 12
- Class F insulation
- Enclosure open, dripproof
- Self-ventilated
- Voltage regulation +/- 1%
- The exciter and generator are to be rated and capable of producing 3x full load current for 10 sec.
- Bearings are to be prelubricated sealed for life ball bearings.

7.7 DC Machine Characteristics:

- 1800RPM
- 250VDC nominal
- 40KW Min. as generator, 75HP as motor
- Temperature rise 80°C over 40°C ambient

- Continuous duty
- Class F insulation
- Enclosure open dripproof
- Self-ventilating
- Speed and voltage regulation +/- 1%
- Brushes shall have minimum 2-year life, and be 'alarmed' for wear, bearings shall be prelubricated sealed for life ball bearings - life expectancy 8 to 10 years.

7.8 One-Way Clutch:

- Complete with shock absorbing engine-clutch adapter coupling.
- Capable of withstanding instantaneous shock and indexing applied full loads to 1 1/2 times rated HP.
- Have long life bearings with provision for grease or oil lubrication.
- Constructed for convenient maintenance without disassembly of engine genset.

8.0 FUEL SYSTEM:

8.1 The fuel system shall consist of:

- Day tank, piping, fill and vent fittings, all valving and a water separating filter for extended filtration.

8.2 Fuel System Operation:

- During operation of the system in the "Diesel ON" mode, when the fuel level drops to a preset level, the fuel transfer pump will start automatically and refill the tank from the main tank to a preset high level. The pump will then shut down.

9.0 EXHAUST SYSTEM:

The exhaust shall consist of the following:

- Silencer, rated for residential silencing to 75 DB(a) at 15.6 metres.
- The silencer shall be side inlet, end outlet configuration for roof, wall or ceiling mounting.
- Piping shall be stainless steel schedule 10, 304L.
- The flexible pipe section shall be a .6096 metre bellows type T321 stainless steel.
- All insulating type wall or roof thimble shall be supplied to conduct and support the pipe through the wall or roof.
- All exhaust piping shall be flange connected with vanstone type of flanges with 56.8-68.19KG/cm^2 backing rings and 510°C gaskets.
- Spring isolating type hangers shall be supplied to support and suspend the exhaust system on the interior of the building.
- A condensate drain is to be provided in the exhaust system, installed so condensate from any source is prevented from entering the engine.
- A rain cap is to be provided with the system if terminating vertically to prevent rain or snow from entering the pipe.

10.0 ENGINE START BATTERY:

- The engine start battery shall as a minimum be 2-12 volt, heavy-duty, lead acid, maintenance-free batteries, with sufficient capacity to crank the engine at starting speed for 1 1/2 min. out of 3 minutes recycling at 15 second intervals: i.e. 15 seconds crank, 15 seconds rest.

- The cables shall be of sufficient size to minimize voltage and current drop to the starter.

- Batteries are to be contained in a suitable metal container with a wood cover over the batteries. (Not to be supported by the batteries.)

11.0 START BATTERY CHARGER:

- Battery charger shall be Mechron solid state static model CR2F rectifier charger, or equal, sized to suit the battery-charging requirements.

- Chargers to have equalize, float, voltage limit and current limit features.

12.0 ENVIRONMENTAL CONTROL SYSTEM:

- Insulated energy saving air inlet and hot air discharge, automatic electrically-controlled dampers shall be supplied to control the temperature in the engine room and provide air for combustion and cooling: complete with operating motors and control mechanism. The damper system shall be complete with rigid formed frames for wall mounting the dampers.

- Sheet metal air inlet and outlet weatherhoods shall be supplied complete with mounting frames and fastenings.

- Thermostats as described in 18.0.

- Environmental control system may be retrofitted to customer's building, provided size, construction and insulation can meet the standards required for satisfactory system function.

13.0 CYCLE CHARGE DC CONTROL PANEL:

- Field controlled automatically to provide generator/charger mode (diesel ON) or motor mode (diesel OFF).

- Charge voltage and current controlled to provide current limit, voltage limit, float and equalize. Screwdriver adjustments. Ripple less than 5 volts RMS at full load.

- Digital meters for battery-charging voltage and current; motor operating voltage and current; 1/2% accuracy.

- Low voltage: red lamp indicator with audible alarm and form C contacts. Low voltage disconnect for battery protection.

- Main breaker, rated for full generator load, with shunt trip.

14.0 CYCLE CHARGE AC CONTROL PANEL:

- AC meter for generator output: voltages line-to-line, line-to-neutral and line current. Switch selectable.

- Optional % load, KVA, KW, separate or switch selectable.

- Frequency meter.

- Elapsed time meter.

- Engine control shall be a static, solid state elecronic control device. It shall perform the following control, alarm and shutdown functions as a minimum:
  . Switch not in AUTO
  . Overcrank
  . Overspeed
  . No speed signal
  . Low oil pressure
  . High coolant temperature
  . Frequency limits fault
  . AC voltage limits fault
  . High DC voltage

- Voltage regulator shall be Basler KR4F or KR7FF or equivalent.

- Current transformer(s) for metering and system control.

- Breaker rated for full load, with trip alarm.

15.0 CYCLE CHARGE SYSTEM CONTROL PANEL:

- Programmable controller, Allen Bradley SLC 100 or equivalent.

- Software by Mechron Energy Ltd.

- Monitor the overall system operation and make logical decisions on system operation to ensure optimal performance and power availbility.

- Monitor the temperature functions (para 18.0) and perform system conrol functions.

- Monitor battery voltage (state of charge), charging current from renewable source (if applicable), charging current status from CC4000. Make logical decisions to optimize the efficiency of battery charging, by minimizing engine run time. Start the standby genset (if applicable) when the battery voltage falls below predetermined threshold.

- Monitor load power, compare to state of charge and charging current from renewable source (if applicable).

- Make logical decisions to run diesel when loads exceed a threshold for a predetermined time. Hold diesel off, at battery recharge point, if renewable source power exceeds a threshold for a predetermined time.

16.0 STATION BATTERY:

- The station battery shall consist of 125 cells, lead acid deep discharge heavy-duty electric batteries, housed in oversized containers to provide extra electrolyte capacity for longer refill intervals. Expected life 10 years. Nominal capacity 1000 ampere hours. Maintenance-free batteries shall be used where required to meet transportation regulations.

- Battery disconnect circuit breaker with trip alarm contacts.

17.0 STATION DISTRIBUTION:

- Main breaker, rated for generator capacity, with trip alarm.

- Distribution panel, 24 poles, breakers and branch circuits provided by installer.

18.0 BUILDINGS:

18.1 General:

- Performance, maintenance and service will be superior if the power system is integrated in factory-built, relocatable shelters. Where not practical, the customer's buildings must be (made) equivalent to the following:

- This system, which includes heating, cooling, ventilation and the equipment shelters, is designed to maximize system efficiency. It provides adequate cooling in the summer months and ensures minimum heat loss during winter months.

- The system is essentially stand alone, with some system controller overrides as described in the following paragraphs.

- Exterior door hardware is extremely rugged freezer door type hardware that maintains its ease of operation and weathertight seal even under the harshest winter conditions.

- Buildings are designed to be maintenance-free.

- Four lifting bolts are available in the lower floor sill approximately 1.828 metres in from each end.

18.2 Heating:

- The building is heated by ceiling-mounted radiant heaters powered from the AC distribution panel. The diesel room(s) has approximately 2KW of heating power and the battery room has approximately 2KW.

- Each room has individual thermostats that are set to turn the heaters on at or below 10°C. The heaters operate independent of other system functions with one exception. The heaters are disabled whenever a diesel starts or when both diesels have failed. When a diesel is running, there is sufficient waste heat to eliminate the need for the heaters. Disabling the heaters also ensures maximum charging current is available for the station battery. The heaters are disabled when diesels fails, to ensure that power for the load is maintained for the maximum length of time. The building is well insulated to minimize heat loss.

18.3 Cooling/Ventilation:

- The genset cooling/ventilation system consists of a dual-port inlet damper and three outlet dampers. This system provides building cooling and engine combustion air.

18.4 Diesel Room Inlet Damper:

- This is a special two-door Mechron low loss damper. This damper is also equipped with an operating motor and control mechanism.

- When the engine starts, the inlet damper will partially open to provide a source of combustion air.

- When the temperature inside the building reaches 26.7°C, the inlet damper (both sides) will fully open. Each side has its own thermostat and actuator.

- The room ventilation fan will be activated when 32.2°C is reached, only if the damper is open. In order to conserve energy during the winter months, this damper will close immediately after diesel shutdown if the outside air temperature is at or below 5°C. Above 5°C, the inlet damper will shut only after the inside temperature falls below 26.7°C. This damper system is powered through a circuit breaker from the AC distribution panel.

18.5 Diesel Room Outlet Damper:

- This damper is a special recirculating damper used to remove diesel cooling air from the building. This damper will open when 26.7°C is reached.

- In order to conserve heat during the winter months, this damper will close immediately after diesel shutdown if the outside temperature (separate thermostats) is at or below 5°C. Above 5°C, the damper will only close after the building temperature falls below 26.7°C.

- The same outside air temperature thermostats are used for the inlet and outlet dampers.

- This damper receives power from the AC output distribution panel.

18.6 Heat Recovery System:

- This system consists of an exhaust fan and diverting damper mounted in an opening in the battery room wall. This wall should adjoin any other building (such as a garage) at the site which can use waste hot air. The priority is to first keep the battery room in a controlled temperature range by blowing hot air from the diesel (recirculating damper in 'recirculating' position) through the battery room to the heat recovery exhaust fan/diverting damper. This fan and damper will operate to exhaust excess hot air, either outdoors or to an adjacent building, depending on the building temperature.

18.7 Battery Room Inlet Damper:

- This damper opens when the battery room temperature is at or above 26.7°C. It has an inlet fan that starts when the temperature is at or above 32.2°C only if the damper is open. The fan and damper receive power through a circuit breaker from the AC station distribution panel.

18.8 Battery Room Outlet Damper:

- This damper opens when the battery room temperature is at or above 26.7°C. It receives its power from the AC generator distribution load panel.

18.9 Diesel Room Building (CC4000 and Standby if applicable):

- This building is a custom-designed Mechron building configured specifically for transportation and operation in remote locations under severe environmental conditions.

- The building is constructed to withstand the rigor of transport to remote locations over rough terrain. The quality of construction is as follows (R factors are for northern Canada):

Floor
- longitudinal sills 15.24 cm structural steel tubing.
- cross sills 10.16 cm formed steel channel on 30.48 cm centres welded to long sills.
- R28 foamed in place polyurethane insulation.
- 3.1750 mm steel (or aluminum) checkerplate over 15.8750 mm plywood.

Walls
- "Z" formed steel 10.16 cm wall studs on 40.64 cm centres.

- R28 foamed in place polyurethane insulation.

- stucco finish aluminum panel over plywood on interior, aluminum panel on exterior.

Roof - one-piece aluminum over plywood.

- R28 foamed in place polyurethane insulation.

18.10 Battery Room Building:

The battery room building is constructed with added insulation for the protection of the batteries and is as follows:

Floor - longitudinal sills 20.32 cm structural steel tubing.

- cross sills 15.24 cm formed steel channel on 30.48 cm centres welded to side sills.

- R42 foamed in place insulation.

- 3.1750 mm steel (or aluminum) checkerplate over 15.8750 mm plywood.

Walls - 15.24 cm formed steel "Z" wall studs on 40.64 cm centres.

- R42 foamed in place insulation.

- stucco finish aluminum panel over plywood on interior, aluminum panel on exterior.

Roof - one-piece aluminum over plywood.

- R42 foamed in place insulation.

19.0 STANDBY GENSET (Option):

19.1 General:

The operation of the standby genset shall be as follows, in the event of failure of the CC4000 system or when it is taken out of service for maintenance or service:

- When the station battery voltage falls to a predetermined minimum setting, or when there is a loss of AC output from the CC4000 genset, the standby genset will start, run and supply the station load under automatic control.

- When the CC4000 set is back in operation, the standby genset will shut down and remain in the Automatic standby mode for further requirements.

19.2 Engine:

For logistic reasons, the engine shall be the same as para 7.2, unless otherwise specified.

19.3 Standby AC Generator:

- 50KW, 62.5KVA, 1800RPM, 60 Hz., .8PF, 120/208 120/240 volts AC, 12 wire reconnectable.
- Single bearing c/w direct connected rotating brushless exciter.
- 80°C rise over 40°C ambient.
- 10% overload 1 hour in 12.
- Continuous duty.
- Class F insulation.
- Enclosure open, dripproof.
- Voltage regulation +/- 1%.
- Self-ventilated.
- Exciter and generator to be capable of producing 3x full load current for 10 sec.
- Bearings are to be prelubricated sealed for life ball bearings.

19.4 Gauges, Accessories, Fuel, Exhaust: per 7.3, 7.4, 8.0, 9.0

19.5 Start Battery and Charger: per paras. 10.0, 11.0

19.6 Standby AC Control Panel:

- Engine Controller per para 14.0, except no high DC voltage function.

- AC Metering, per para 14.0.

- Main Breaker, rated for generator capacity, with trip alarm.

- Basler automatic voltage regulator, will maintain the voltage within +/- 1%.

19.7 Transfer Panel: (If Standby Genset option is exercised)

- The transfer switch shall be a 3 pole, 120/240, single phase, 300 amp Robonic or ASCO transfer switch with auxiliary start contacts, relays and timers for normal and emergency source operation and transfer of the station load, between the CC4000 and standby gensets. It will be equipped with a test switch and normal and emergency contactor closing counters.

- The transfer switch shall be installed in a free standing cubicle and shall be prewired to terminal blocks within the cubicle for input and load connections for both generator sets.

20.0 INSTALLATION:

20.1 Equipment shelters or buildings:

- All the equipment described herein shall be installed in the respective shelters if specified by the customer or in the customer's building and generally in accordance with the drawings supplied. If relocatable shelters are to be supplied, it will require 3 shelters to house the equipment specified. If the customer's building is to be used, it will require space 4.8768 W x 12.192 metres L.

20.2 Drawings:

- The following drawings show electrical and mechanical configurations:

  C00334 General Arrangement for CYCLE CHARGE 4000
  (The genset unit)
  B00288 CYCLE CHARGE 4000 Control Cubicles (The controls)
  B00290 General Arrangement for CYCLE CHARGE Standby Generator
  (The genset unit)
  C00323 CYCLE CHARGE 4000 Single Line Diagram

- The following drawings show floor plans and wall elevations for a system installed in a fixed building of conventional construction, size 4.8768 W x 12.192 metres L:

  C00324 CYCLE CHARGE 4000 Floor Plan
  - Genset and Battery Plan
  C00325 CYCLE CHARGE 4000 Engine Room and Battery Room
  - End Wall Elevations
  C00326 CYCLE CHARGE 4000 Engine Room and Battery Room
  - Side Wall Elevations

- The following drawings show the floor plans for a system installed in the Mechron relocatable shelters:

  C00361 CYCLE CHARGE 4000, Floor Plan for CYCLE CHARGE Genset Shelter
  C00362 CYCLE CHARGE 4000, Floor Plan for Station Battery Shelter
  C00363 CYCLE CHARGE 4000, Floor Plan for Standby Genset Shelter
  D00344 Floor Plans for CC4000: Genset Shelter, Station Battery Shelter & Standby Genset Shelter.

20.3 General:

- All equipment shall be new and best quality available.

- All electrical conduit, wiring, outlet switches, fixtures, fans, load centres, circuit breakers, and all items comprising the electrical system shall be supplied and installed in accordance with good engineering practice and to national and local electrical codes.

- The day tank fuel system shall be installed in accordance with good engineering practice and to regulations governing the installation of internal combustion engines and oil-burning equipment. Rigid copper pipe shall be used for fill, vent, suction and discharge lines, a flexible section shall be used in each line at the transfer pump connection. Fuel supply and return lines to the engines shall be 9.525 mm copper tubing with flexible sections at engine connections.

- The gensets shall be placed, levelled and secured in the place designated on the drawing supplied or to customer's drawings if installed in his buildings.

- The exhaust system shall be suspended from the ceiling using spring-loaded adjustable hangers.

- All interior exhaust piping and silencers shall be insulated with calcium silicate insulation to a density sufficient to reduce the surface temperature to 82°C at a 26.7°C ambient.

- All environmental control system items shall be installed on the interior walls with a flexible connection to the engine from the automatic air discharge recirculating damper.

- Inlet and outlet weatherhoods shall be installed on the exterior of the shelter or building.

- Control cubicles shall be placed and secured in the space provided.

- All wiring between the cubicles and gensets and all electrically-operated devices within the diesel rooms shall be supplied and installed.

- Station batteries will be placed, levelled and secured in the space provided, interconnecting wiring supplied and installed between cell units, and input/output wiring supplied between batteries and the control cubicle system.

20.4 Estimated Weights:

- See table, for 50KW system

21.0 TRANSPORT:

- If equipment is to be installed in relocatable shelters, all heavy equipment could be removed for transport for unit shipment or left in place for transport by heavy lift aircraft or surface transport.

TABLE OF ESTIMATED WEIGHTS

50KW CC4000 SYSTEM

	LB	KG
A. SYSTEM TO BE INSTALLED IN OWNER'S BUILDING		
1. CYCLE CHARGE 4000 Genset and associated equipment	7,155	3,252
2. Batteries, racks, intercell connectors	31,000	14,091
3. Standby Genset, with associated equipment including transfer switch	5,845	2,657
TOTAL	44,000	20,000
B. MECHRON 'PACKAGED SYSTEM'		
1. CYCLE CHARGE 'Module' c/w equipment installed	12,700	5,792
2. Battery 'Module' c/w equipment installed	36,000	16,363
3. Standby 'Module' c/w equipment installed	10,800	4,910
TOTAL	59,500	27,045

22.0 TESTS:

- Design verification testing will be carried out after completion of assembly of the first unit of new design. This test will be carried out over a period preferably of six months in order to have outside ambients of sufficient severity and wide range of temperature for evaluation tests.

- Factory acceptance inspection and test will be carried out on each production system in accordance with manufacturer's procedures. These tests may be witnessed by the customer's representtives.

- Field tests would be carried out after completion of installation to ensure that all equipment was properly installed and operating as per specifications. This test would be performed over a period of 5 days' duration to ensure adequate cycling of the genset/battery system.

23.0 DOCUMENTATION FOR OPERATION, MAINTENANCE AND SERVICE:

- A complete equipment manual shall be supplied to the customer. This manual will include instruction, parts and operational books for the engine gensets and all items comprising the total equipment package.

24.0 WARRANTY:

- The equipment supplied shall be covered by the Mechron Standard Warranty.

25.0 PERFORMANCE MONITORING (Option):

25.1 General:

- A microcomputer-based performance monitoring option may be incorporated at the site to:
  . log alarms and shutdown data, to provide historical information for analysis and corrective measures.
  . to provide % power availability of the CC4000 and operating hours of the standby diesel.
  . to permit comparison of the CC4000 system performance in absolute terms and for comparison with conventional prime power systems. Suggested data acquisition, for performance monitoring, is given on the following table.

PERFORMANCE MONITORING TABLE

1. Sampling rate: every minute.

2. Reporting intervals: weekly and monthly

3. Performance Reporting:

   1) KWh Generated (Gross) (power into battery, including any runs to generate heat)
   2) KWh to Load (Net)
   3) Run Time (Hours)
   4) Off Time (Hours)
   5) % Run (current week)
      (current month)
      (cumulative year to date)
   6) Fuel Consumed (current week)
      (current month)
      (cumulative year to date)

	GROSS	NET
7) KWh Per Litre - current week - current month - cumulative year to date		

	HI	MEAN	LOW
8) Outside Air Temperature - current week - current month			
9) Inside Air Temperature - current week - current month			
10) Battery Voltage - daily report			

APPENDIX A-4

Drawings

The following drawings show electrical and mechanical configurations:

C00334 General Arrangement for CYCLE CHARGE 4000 (The genset unit)
B00288 CYCLE CHARGE 4000 Control Cubicles (The controls)
B00290 General Arrangement for CYCLE CHARGE Standby Generator (The genset unit)
C00323 CYCLE CHARGE 4000 Single-Line Diagram

The following drawings show floor plans and wall elevations for a system installed in a fixed building of conventional construction, size 4.87 m W x 12.192 m L:

C00324 CYCLE CHARGE 4000 Floor Plan
- Genset and Battery Plan

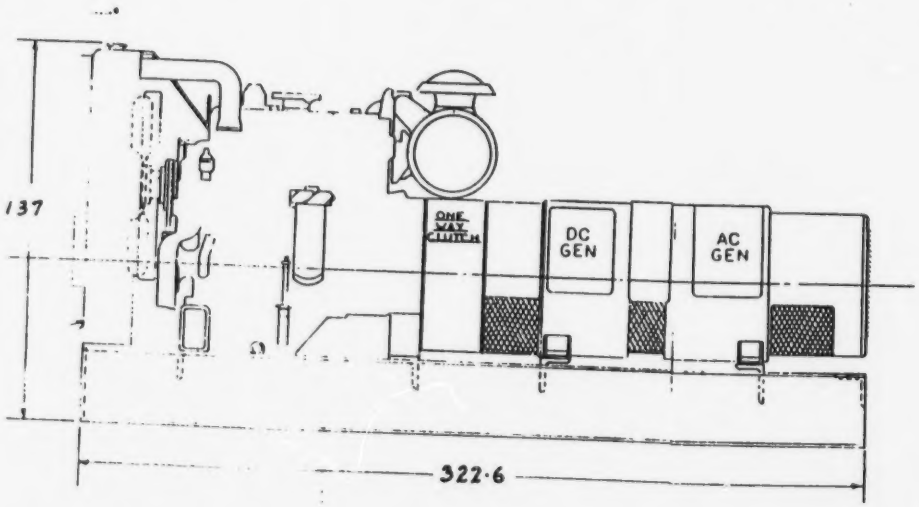
C00325 CYCLE CHARGE 4000 Engine Room and Battery Room
- End Wall Elevations

C00326 CYCLE CHARGE 4000 Engine Room and Battery Room
- Side Wall Elevations

The following drawings show the floor plans for a system installed in the Mechron relocatable shelters:

C00361 CYCLE CHARGE 4000, Floor Plan for CYCLE CHARGE Genset Shelter
C00362 CYCLE CHARGE 4000, Floor Plan for Station Battery Shelter
C00363 CYCLE CHARGE 4000, Floor Plan for Standby Genset Shelter

D00344 Floor Plans for CC4000: Genset Shelter, Station Battery Shelter & Standby Genset Shelter



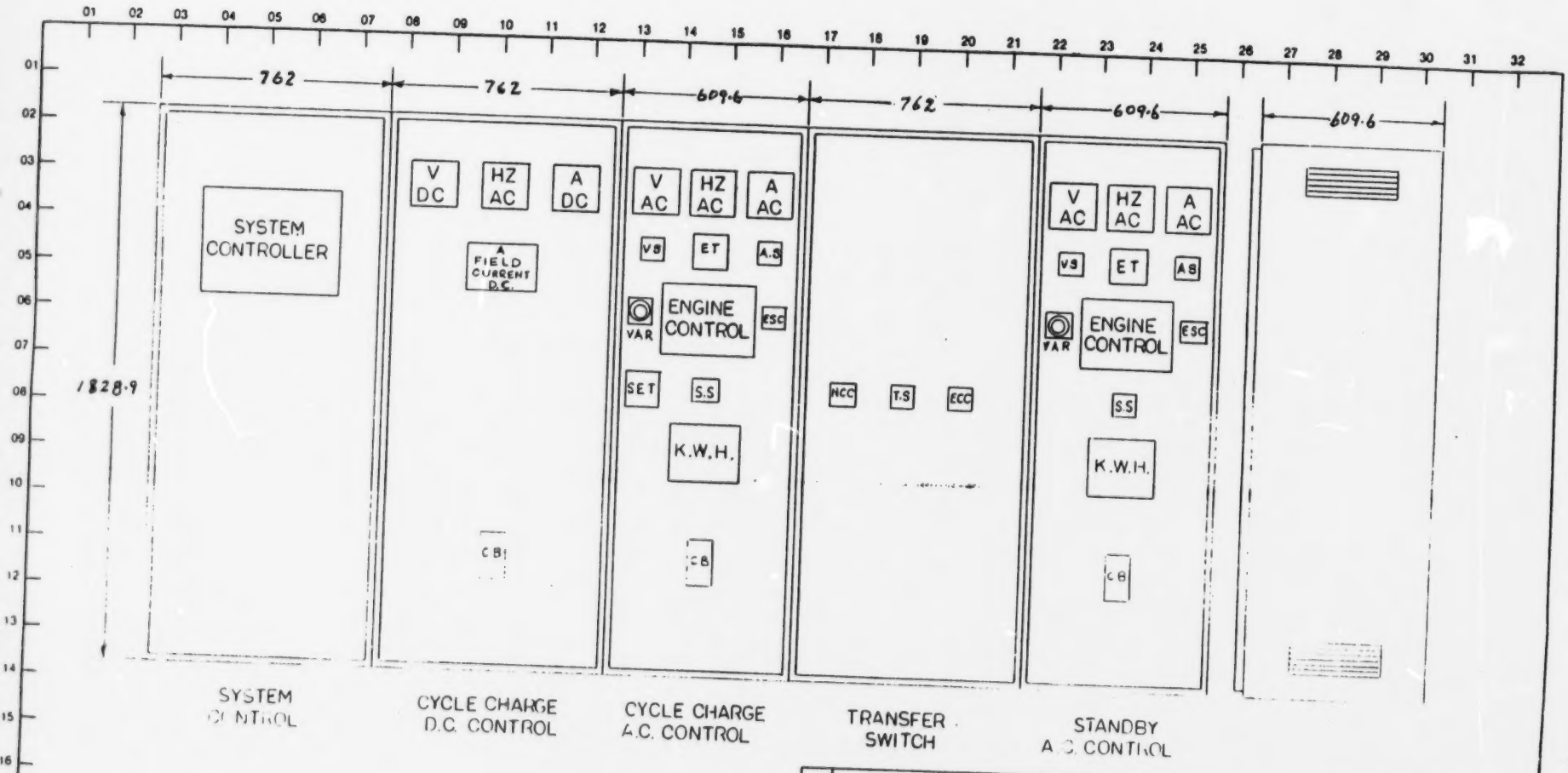
MECHRON

GENERAL ARRANGEMENT FOR CYCLE CHARGE 4000

E. LANGFORD

CONFIDENTIALITY

C00334



MECHRON
Mechron Energy Ltd.

CYCLE CHARGE 4000
CONTROL CUBICLES

DESIGNED E LANGFORD
DRAWN FURGESON
CHECKED
APPROVED
DATE

CONFIDENTIALITY
"This drawing contains confidential design information which is the property of Mechron Energy Ltd. and is provided only for customer information. It is to be carefully guarded from showing by all others and may not be loaned or used for any purpose whatsoever except by express and written permission of

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DRAWING NUMBER B00288

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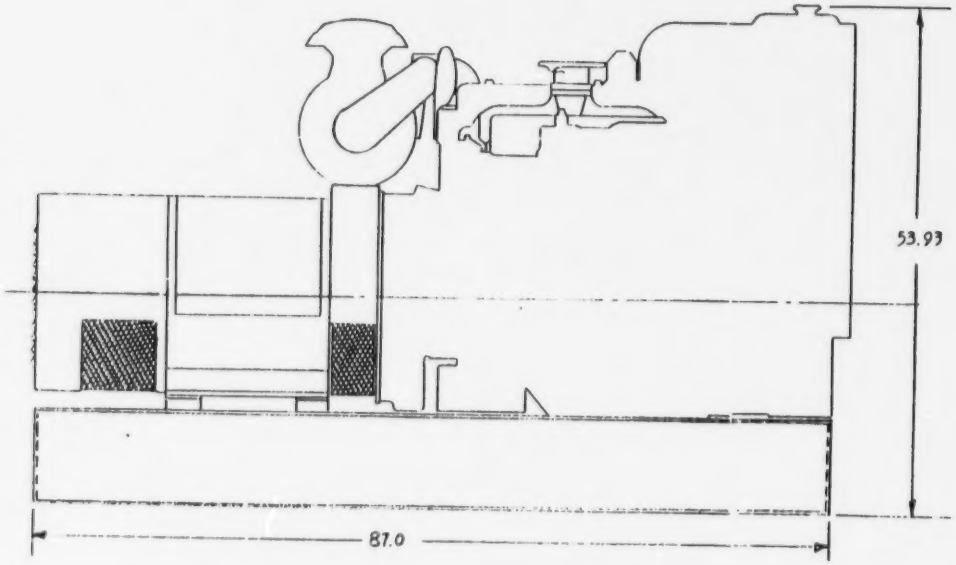
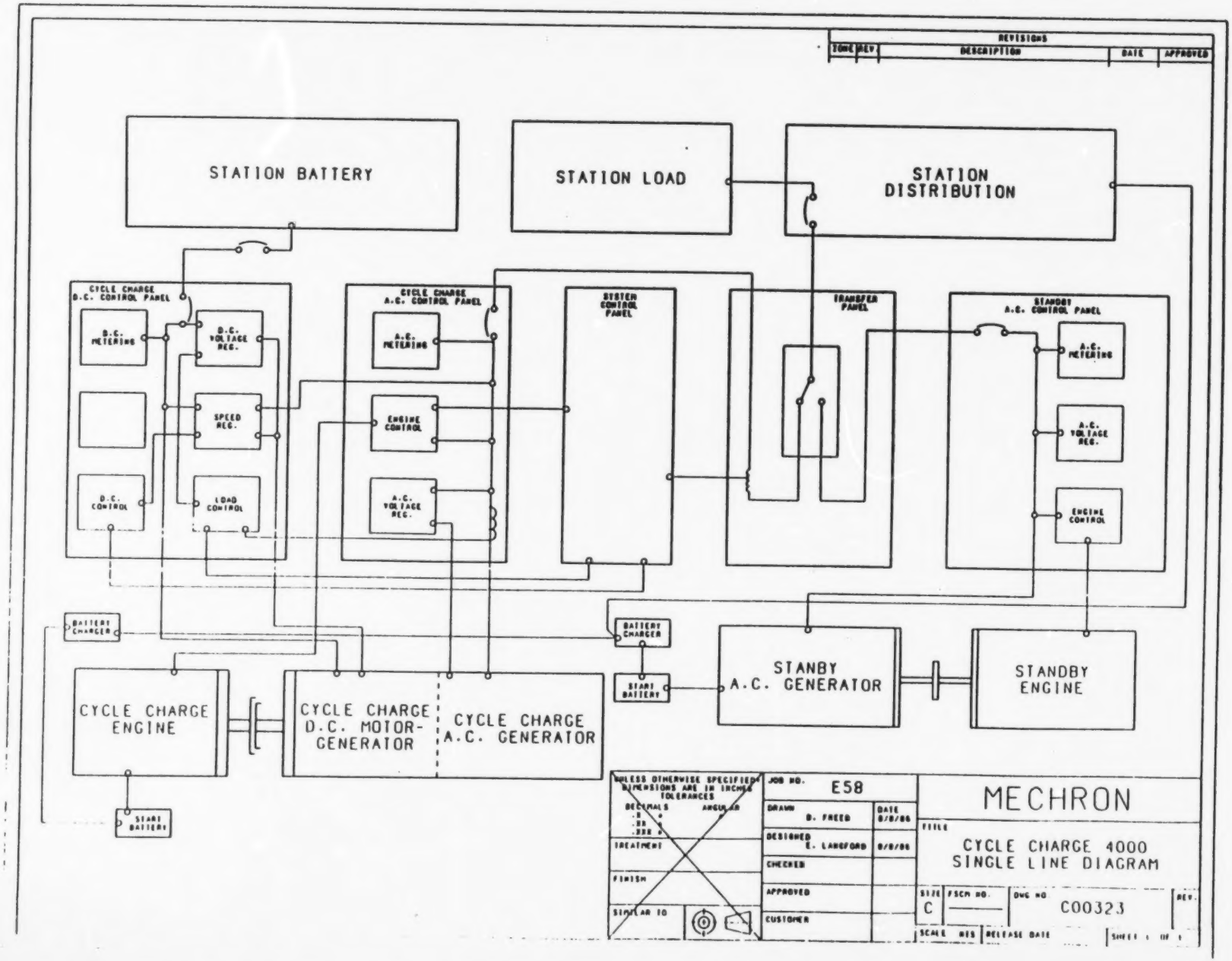


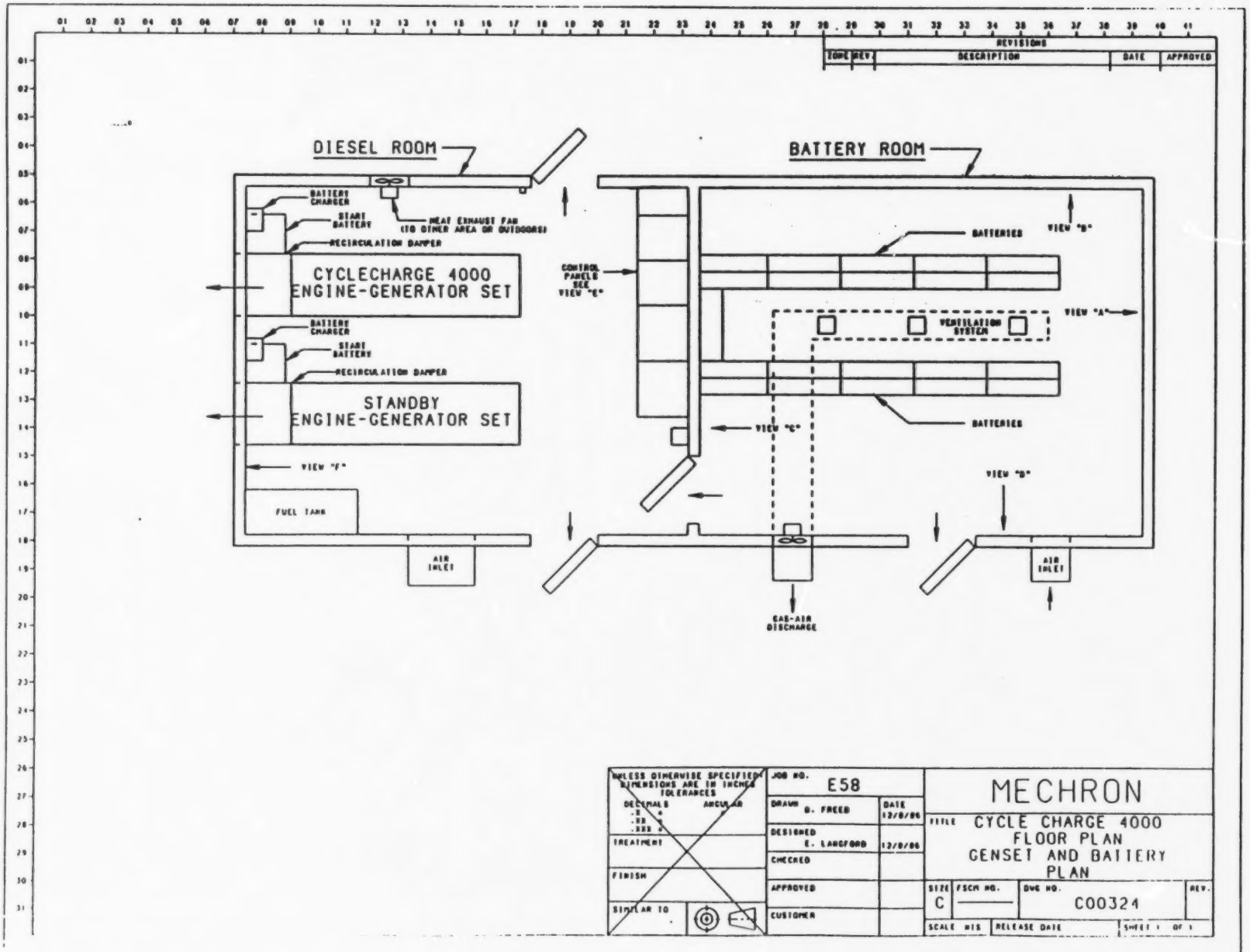
MECHRON
Mechron Energy Ltd.

GENERAL ARRANGEMENT FOR
CYCLE CHARGE STANDBY GENERATOR

DESIGNED HILTZ	CONFIDENTIALITY "This drawing contains confidential design information which is the property of Mechron Energy Ltd and is provided only for customer information. It is to be carefully guarded from viewing by all others and may not be loaned or used for any purpose whatsoever except by expressed and written permission of Mechron	DWG NO E58	
DRAWN FURGESON		REF DWG	
CHECKED		SCALE NTS	SHEET 1 OF 1
APPROVED		DRAWING NUMBER	
DATE			

REV | DESCRIPTION | APPR | DATE
ISSUE DATE


REVISIONS
ZONE
REV
DESCRIPTION
DATE
APPROVED
STATION BATTERY
STATION LOAD
STATION DISTRIBUTION
CYCLE CHARGE D.C. CONTROL PANEL
D.C. METERING
D.C. VOLTAGE REG.
SPEED REG.
D.C. CONTROL
LOAD CONTROL
CYCLE CHARGE A.C. CONTROL PANEL
A.C. METERING
ENGINE CONTROL
A.C. VOLTAGE REG.
SYSTEM CONTROL PANEL
TRANSFER PANEL
STANDBY A.C. CONTROL PANEL
A.C. METERING
A.C. VOLTAGE REG.
ENGINE CONTROL
BATTERY CHARGER
BATTERY CHARGER
START BATTERY
START BATTERY
STANBY A.C. GENERATOR
STANDBY ENGINE
CYCLE CHARGE ENGINE
CYCLE CHARGE D.C. MOTOR-GENERATOR
CYCLE CHARGE A.C. GENERATOR
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES
DECIMALS
ANGULAR
TREATMENT
FINISH
SIMILAR TO
JOB NO.
E58
DRAWN
D. FREED
DESIGNED
E. LANGFORD
CHECKED
APPROVED
CUSTOMER
MECHRON
TITLE
CYCLE CHARGE 4000
SINGLE LINE DIAGRAM
SIZE
C
FSCM NO.
DWG NO
C00323
REV.
SCALE
RELEASE DATE
SHEET 1 OF 1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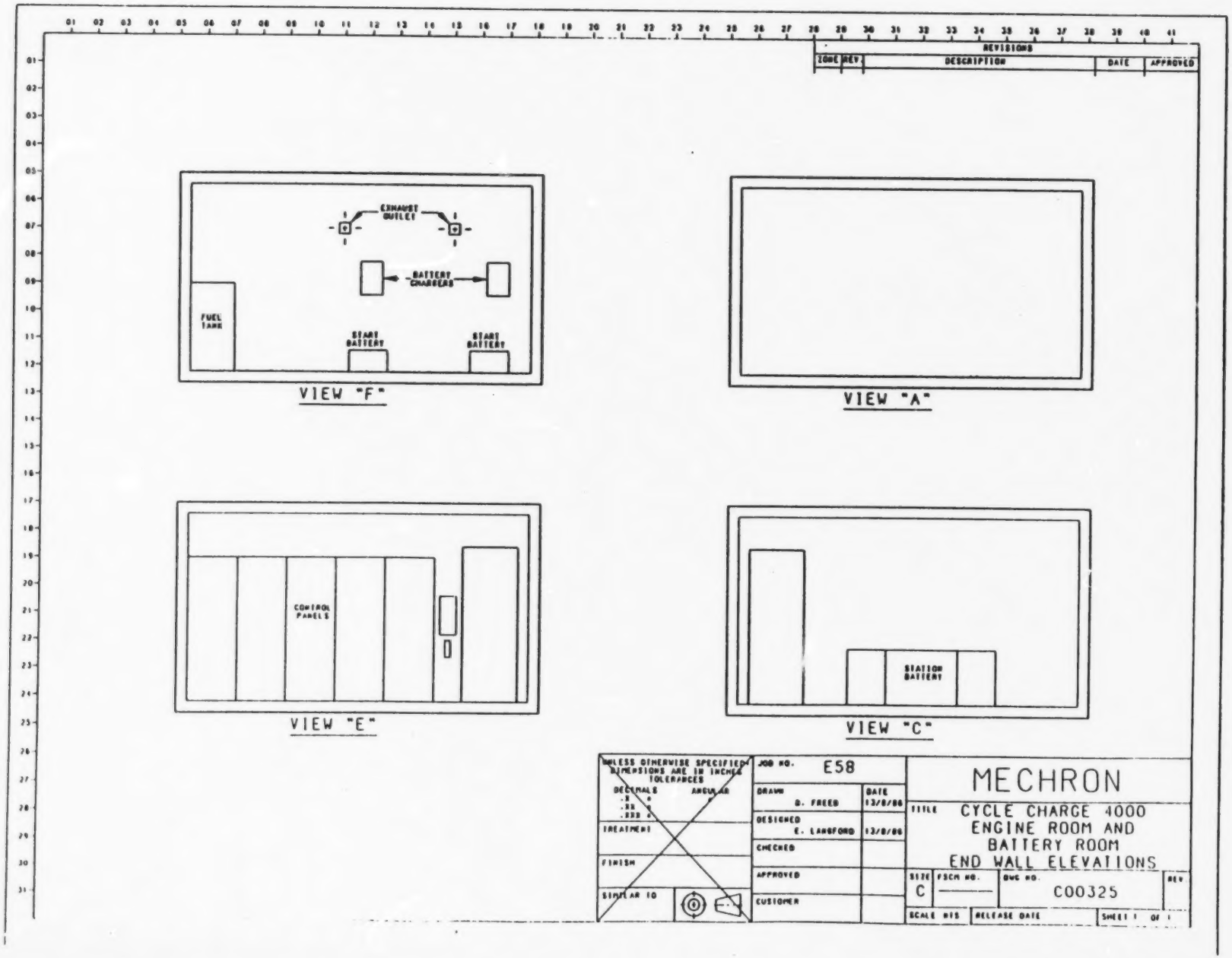
ZONE
REV.
DESCRIPTION
DATE
APPROVED
DIESEL ROOM
BATTERY CHARGER
START BATTERY
HEAT EXHAUST FAN (TO OTHER AREA OR OUTDOORS)
RECIRCULATION DAMPER
CYCLECHARGE 4000 ENGINE-GENERATOR SET
BATTERY CHARGER
START BATTERY
RECIRCULATION DAMPER
STANDBY ENGINE-GENERATOR SET
VIEW "F"
FUEL TANK
AIR INLET
CONTROL PANELS SEE VIEW "E"
BATTERY ROOM
BATTERIES
VIEW "B"
VIEW "A"
VENTILATION SYSTEM
BATTERIES
VIEW "C"
VIEW "D"
AIR INLET
GAS-AIR DISCHARGE
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES
DECIMALS
ANGULAR
TREATMENT
FINISH
SIMILAR TO
JOB NO.
E58
DRAWN
D. FREED
DATE 12/8/86
DESIGNED
E. LANGFORD
12/8/86
CHECKED
APPROVED
CUSTOMER
MECHRON
TITLE
CYCLE CHARGE 4000
FLOOR PLAN
GENSET AND BATTERY
PLAN
SIZE
C
FSCM NO.
DWG NO.
C00324
REV.
SCALE NTS
RELEASE DATE
SHEET 1 OF 1


REVISIONS
ZONE
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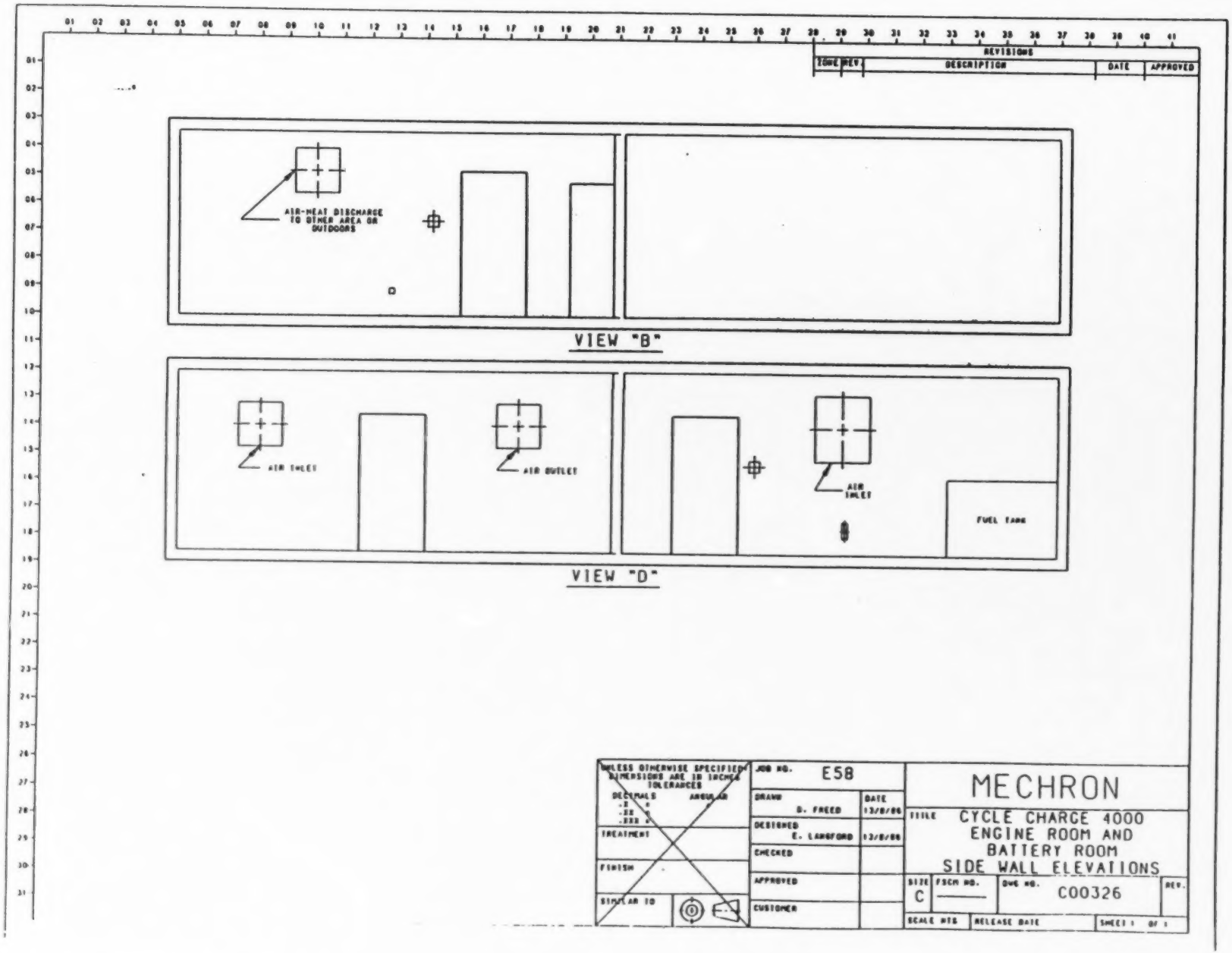
DESCRIPTION
DATE
APPROVED
EXHAUST OUTLET
BATTERY CHARGERS
FUEL TANK
START BATTERY
START BATTERY
VIEW "F"
VIEW "A"
CONTROL PANELS
VIEW "E"
STATION BATTERY
VIEW "C"
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES
DECIMALS
ANGULAR
TREATMENT
FINISH
SIMILAR TO
JOB NO. E58
DRAWN D. FREED
DATE 13/8/86
DESIGNED E. LANGFORD
13/8/86
CHECKED
APPROVED
CUSTOMER
MECHRON
TITLE CYCLE CHARGE 4000 ENGINE ROOM AND BATTERY ROOM END WALL ELEVATIONS
SIZE C
FSCM NO.
DWG NO. C00325
REV
SCALE NTS
RELEASE DATE
SHEET 1 OF 1


REVISIONS
ZONE
REV.
DESCRIPTION
DATE
APPROVED
AIR-HEAT DISCHARGE TO OTHER AREA OR OUTDOORS
VIEW "B"
AIR INLET
AIR OUTLET
AIR INLET
FUEL TANK
VIEW "D"
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES
DECIMALS
ANGULAR
TREATMENT
FINISH
SIMILAR TO
JOB NO. E58
DRAWN D. FREED
DATE 13/8/86
DESIGNED E. LANGFORD
13/8/86
CHECKED
APPROVED
CUSTOMER
MECHRON
TITLE CYCLE CHARGE 4000 ENGINE ROOM AND BATTERY ROOM SIDE WALL ELEVATIONS
SIZE C
FSCM NO.
DWG NO. C00326
REV.
SCALE NTS
RELEASE DATE
SHEET 1 OF 1

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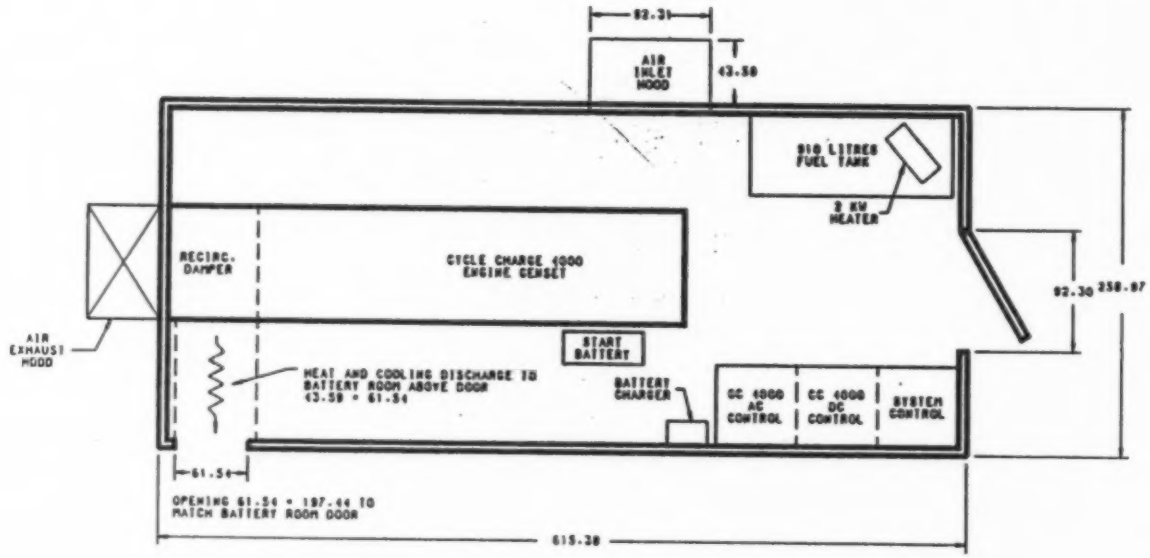

NOTES-

(1) ALL DIMENSIONS ARE IN CENTIMETERS

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .X ± .XX ± .XXX ± ANGULAR ±	JOB NO. E58		MECHRON
	DRAWN D. FREED	DATE 11/11/86	TITLE CYCLE CHARGE 4000 FLOOR PLAN FOR CYCLE CHARGE GENSET SHELTER
TREATMENT	DESIGNED E. LANGFORD	11/11/86	
	CHECKED		
FINISH	APPROVED		SIZE C / FSCM NO. / DWG NO. C00361 / REV. A
SIMILAR TO	CUSTOMER		SCALE NS / RELEASE DATE / SHEET 1 OF 1

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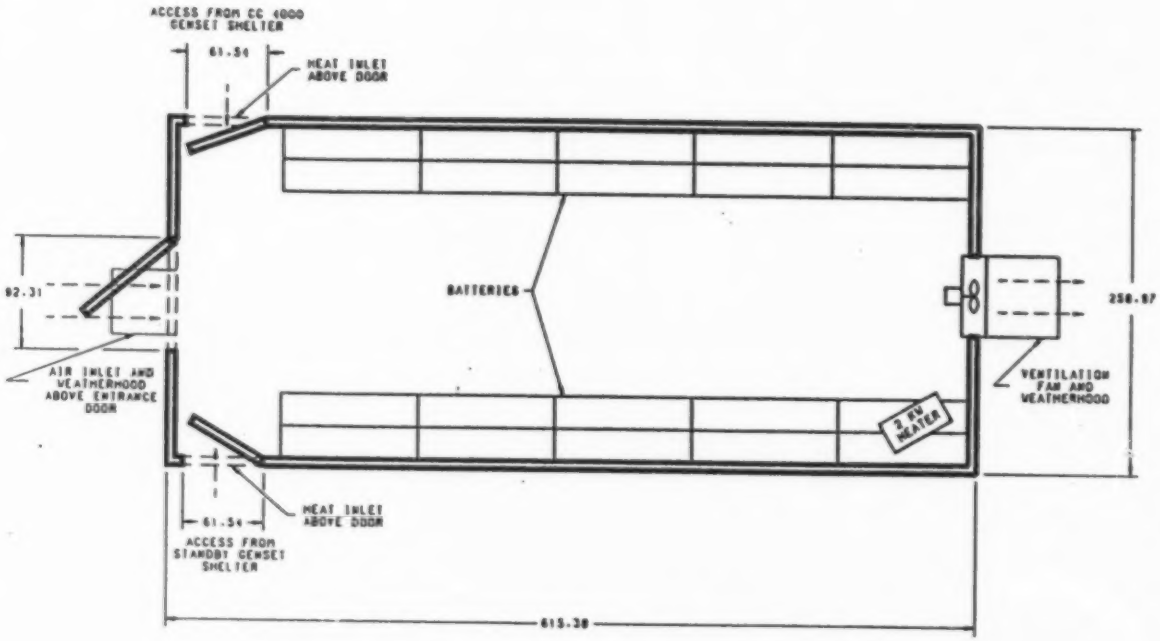

NOTES:

(1) ALL DIMENSIONS ARE IN CENTIMETERS.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .X ± .XX ± .XXX ± ANGULAR ±	JOB NO. E58		MECHRON
	DRAWN D. FREED	DATE 11/11/86	TITLE CYCLE CHARGE 4000 FLOOR PLAN FOR STATION BATTERY SHELTER
TREATMENT	DESIGNED E. LANGFORD	11/11/86	
FINISH	CHECKED		
SIMILAR TO	APPROVED		SIZE C / FSCM NO. / DWG NO. C00362 / REV A
	CUSTOMER		SCALE NS / RELEASE DATE / SHEET 1 OF 1

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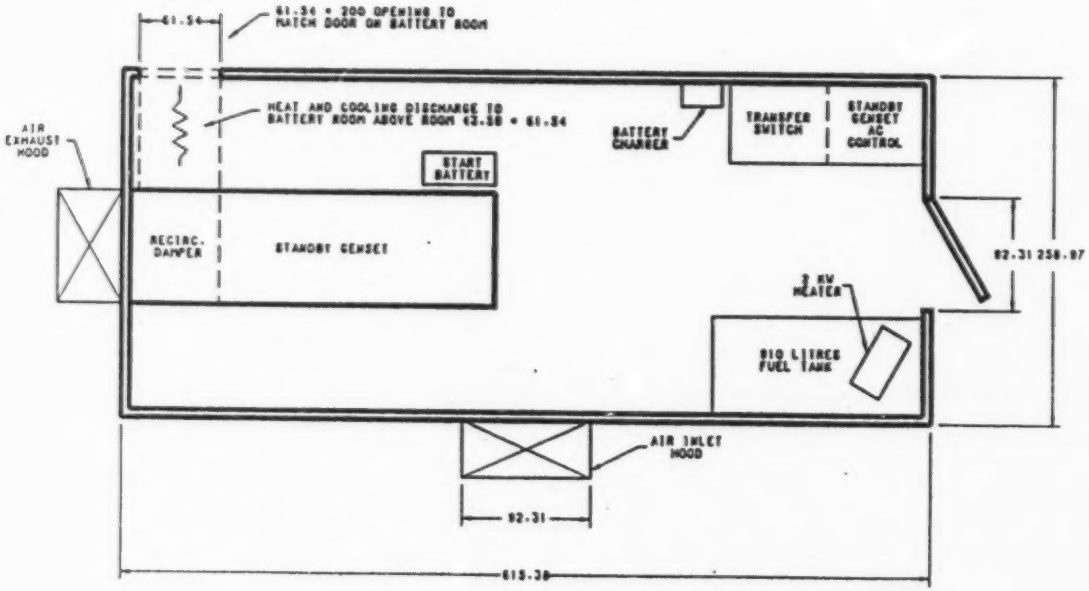


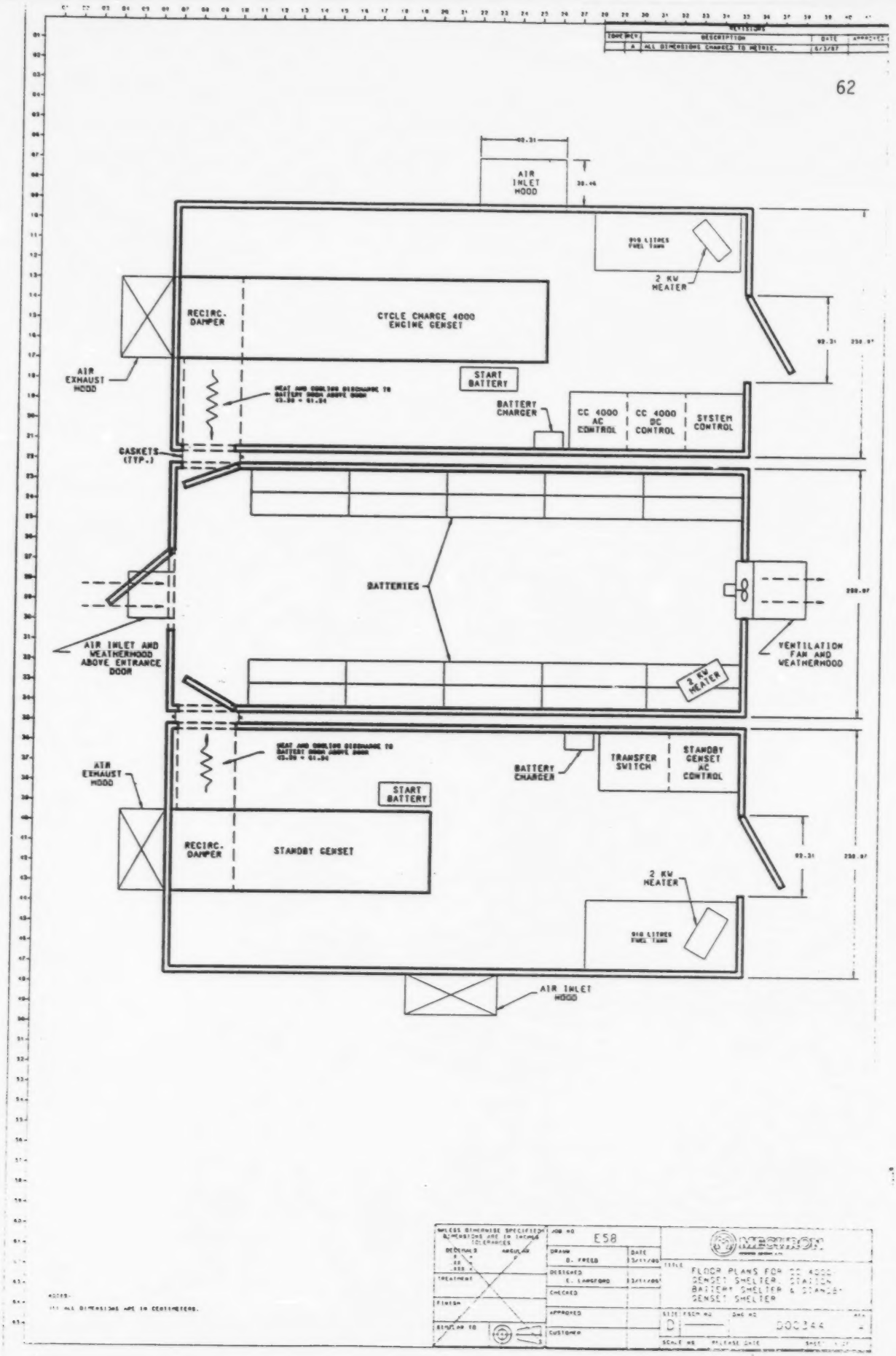
NOTES:
(1) ALL DIMENSIONS ARE IN CENTIMETERS.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .X ± .XX ± .XXX ± ANGULAR ±	JOB NO. E58	MECHRON
TREATMENT	DRAWN D. FREED	DATE 12/11/86
FINISH	DESIGNED E. LANGFORD	DATE 12/11/86
SIMILAR TO	CHECKED	
	APPROVED	
	CUSTOMER	

TITLE
CYCLE CHARGE 4000
FLOOR PLAN FOR
STANDBY GENSET SHELTER

SIZE	FSCM NO.	DWG NO.	REV
C	—	C00363	A

SCALE NS | RELEASE DATE | SHEET 1 OF 1


REVISIONS
ZONE REV DESCRIPTION DATE APPROVED
A ALL DIMENSIONS CHANGED TO METRIC. 6/3/87
AIR INLET HOOD
2 KW HEATER
RECIRC. DAMPER
CYCLE CHARGE 4000 ENGINE GENSET
AIR EXHAUST HOOD
START BATTERY
BATTERY CHARGER
CC 4000 AC CONTROL
CC 4000 DC CONTROL
SYSTEM CONTROL
GASKETS (TYP.)
BATTERIES
AIR INLET AND WEATHERHOOD ABOVE ENTRANCE DOOR
VENTILATION FAN AND WEATHERHOOD
2 KW HEATER
AIR EXHAUST HOOD
BATTERY CHARGER
TRANSFER SWITCH
STANDBY GENSET AC CONTROL
START BATTERY
RECIRC. DAMPER
STANDBY GENSET
2 KW HEATER
AIR INLET HOOD
NOTES:
ALL DIMENSIONS ARE IN CENTIMETERS.
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES
DECIMALS ANGULAR
TREATMENT
FINISH
SIMILAR TO
JOB NO E58
DRAWN D. FREED
DESIGNED E. LANGFORD
CHECKED
APPROVED
CUSTOMER
TITLE FLOOR PLANS FOR CC 4000 GENSET SHELTER, STATION BATTERY SHELTER & STANDBY GENSET SHELTER
SIZE D
DWG NO D00344
SCALE NS
RELEASE DATE

APPENDIX A-5

Price Summary

APPENDIX A-5

PRICE SUMMARY

INTRODUCTION

The following prices for a 50KW system are budgetary, FOB Mechron, Federal and Provincial taxes extra. The prices do not include any fixed (non-recurring) engineering costs.

A. SYSTEM TO BE INSTALLED IN OWNER'S BUILDING

1. CYCLE CHARGE 4000 Genset	112,000.
2. a) Batteries, racks [1]	55,000.
TOTAL	167,000.
b) Add for sealed maintenance-free batteries [2]	14,600.
TOTAL	181,600.
3. Standby Diesel Genset (OPTION)	44,200.
4. Installation Materials [3]	17,800.
5. Installation Labour + Expenses [3]	41,100.

B. SYSTEM INSTALLED IN MECHRON RELOCATABLE SHELTERS

1. CYCLE CHARGE 4000 Genset in shelter #1	130,200.
2. a) Batteries, racks [1] in shelter #2	75,700.
TOTAL	205,900.
b) Add for sealed maintenance-free batteries [2]	14,600.
TOTAL	220,500.
3. Standby Diesel Genset in shelter #3 (OPTION)	62,300.
4. Installation Materials [3]	17,800.
5. Installation Labour [3]	14,000.

NOTES

1. Based on deep-cycle lead acid batteries
2. Based on Absolyte or equivalent batteries
3. Subtract 25%, if Standby option is not included